Popular Astronomy.

Vol. XXV, No. 1. JANUARY, 1917. Whole No. 241

JUPITER IN 1915-1916.

LATIMER J. WILSON.
PRESIDENT OF THE SOCIETY FOR PRACTICAL ASTRONOMY.

Numerous observations of Jupiter were made with the 11-inch reflector at Nashville, Tenn., and with the 21-inch refractor of the Bausch and Lomb Observatory at Rochester, New York. Mr. A. F. Kohlman has also reported a number of observations made with a four-inch refractor and an eight-inch reflector at Milwaukee, Wis. His drawings are in accord with my own and show considerable detail.

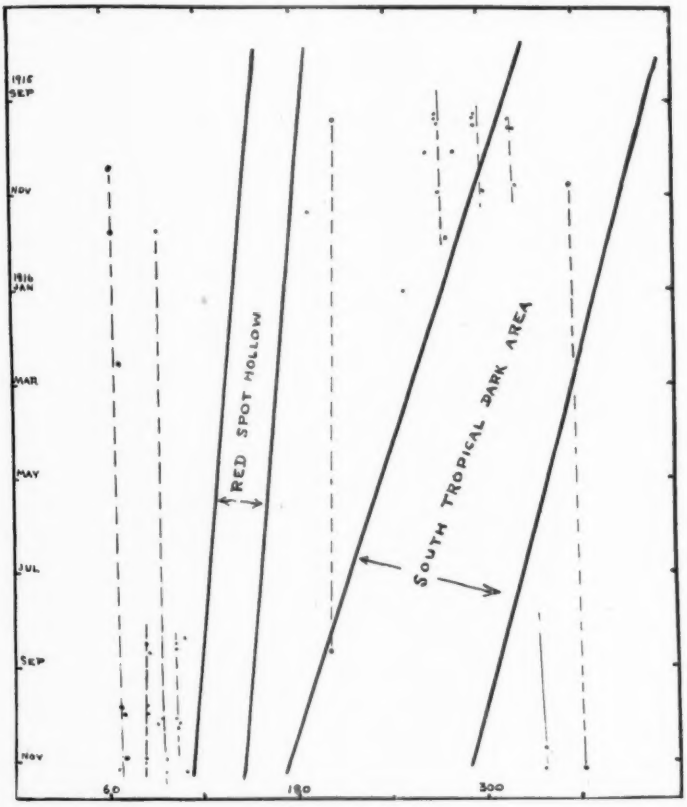
The Red Spot.

In 1915 the red spot hollow was on that side of Jupiter nearly midway between the preceding and the following parts of the great South Tropical disturbance, indicated on the chart as the South Tropical Dark Area. In 1913 the red spot was involved in the south tropical disturbance, and the preceding part of the disturbance will again reach the red spot about the first of the year (1917). In 1915 the outline of the red spot itself was occasionally seen, and was quite distinctly seen on November 6, 1916. The general tone of the whole region including the red spot hollow and the preceding part of the south tropical disturbance is less brilliant than in 1915. From August 10, 1915 to November 8, 1916 the red spot has decreased from longitude 171° (center) to 132° (center). The motion of the spot from August to November 1916 is very slow as can be seen from the table, 0.05 degrees per day. The red spot in 1915 and 1916 was about 30 degrees long.

The South Tropical Disturbance.

This is the most extensive dark marking on the planet and the motion of its preceding and following parts, distinguished by white loops, affords an opportunity for serious consideration. The preceding part of the disturbance had a mean motion of 0.35 degrees per day in 1913,

0.27 degrees in 1914 and about 0.18 in 1915. The rapid motion of the disturbance in 1913 seemed to be associated with the rapid motion of the red spot that year, 0.15 degrees per day. The average rate of the preceding part of the south tropical dark area is about 0.3 degrees



JUPITER 1915-1916.

The mean motion of the South Tropical Dark Area and the Red Spot Hollow, and principal spots in the northern equatorial belt (dotted lines).

daily for 1915-16. Has the approach of the area to the red spot at present anything to do with this increase in its motion? The preceding loop of the disturbance is now (November, 1916) moving forward in decreasing longitude more rapidly than the following part and therefore the dark area is lengthening. In 1915 the entire area was 87 degrees long while on November 6, 1916 it is 131 degrees in length. In May

1913 it was about 141 degrees and in September 1914 it measured 110 degrees. The rotation period of the preceding part is now 9 hours 55 minutes 25.2 seconds; the following part is 9 hours 55 minutes 40.4 seconds. The telescopic aspect of the disturbance is considerably different this year from its appearance in the recent apparitions. It is now diffused and faint, and in color dusky and brick-red; these are the chief characteristics. Perhaps the tilt of the southern hemisphere away from us at present partially accounts for this.

The Spots in the Northern Equatorial Belt.

The darkening of this belt, which began or rather was renewed in 1912, assumed an arrangement of dark spots at intervals of from 15 to 17 degrees all around the planet in 1913 and 1914. Dark spots appeared in the northern component of the belt in 1915, several very intense elliptical spots from three to ten thousand miles long being conspicuous directly north-preceding the south tropical dark area in September 1915. The dotted lines on the chart show my attempt to identify these markings. They are evidently moving with the general drift of System II. There are indications of a possible slower motion in some of them. At present there are three very intense spots in longitudes 61, 86 and 107 degrees, north latitude 14 degrees (approximately). Very brilliant white spots are associated with them on the north, in the northern tropical zone.

From considerations of Jupiter it may be possible to determine the character of these spots and the cause of the darkness of the belts. The telescopic aspect of the dark spots is very similar to sunspots; there is a dark umbra and a faint border somewhat similar to the penumbra of spots on the sun. Intensely white strips usually border the spots on the edge involved in the dark belt. Perhaps it can be shown that the spots are areas of relatively cool vapors descending as high pressure areas, while the white spots are masses of the Jovian atmosphere heated from within and ascending as gigantic vortices, tornadoes whose upper surface appears to us as great white domes.

A more careful and prolonged systematic observation of these markings is needed to determine their various motions. Any observers with suitable telescopes are invited to join the Planetary and Lunar Section of the Society for Practical Astronomy and coöperate in this branch of research.

The Preceding Part of the Red Spot Hollow.

	G.M.T. h	m	○	
1915 Aug. 10*	17	25	161	System II
" 24	18	40	152	
Sept. 3	16	57	154	
" 13	15	10	153	
" 25	15	6	155	
" 27	16	37	151	
Oct. 2	15	47	153	
" 14*	15	35	149	

	G.M.T. h	m	○	
1916 Aug. 15	18	45	120	System II
" 20	17	54	121	
Oct. 3	14	4	118	
" 5	15	35	114	
Nov. 6	12	0	117	

Following Part of the Red Spot Hollow.

	G.M.T. h	m	○	
1915 Aug. 3	17	22	187	System II
" 15*	17	10	184	
Sept. 11	14	30	188	
" 13	16	5	186	
" 25	15	57	186	
" 27	17	33	185	
Oct. 2			188	
" 12*	15	0	188	

	G.M.T. h	m	○	
1916 Jan. 2	12	52	184	System II
Aug. 6	17	17	154	
" 18	17	10	154	
" 20	18	40	149	
Sept. 11	16	50	150	
Oct. 3	15	56	149	
" 10	15	40	149	
" 24	17	15	152	
Nov. 6	12	50	147	

The Preceding Part of the South Tropical Disturbance

	G.M.T. h	m	○	
1915 July 23	17	15	328	
Sept. 9	16	23	316	
" 16	17	5	314	
" 28*	16	45	311	
Oct. 3	15	59	310	
" 6	13	30	311	
" 23*	12	43	318	
" 29	17	15	304	

	G.M.T. h	m	○	
1916 Aug. 16	16	39	194	
" 18	18	20	196	
" 28	16	21	187	(Bad seeing)
Sept. 9	16	24	193	
Oct. 3	15	57	186	
" 8	14	57	182	
Nov. 9	13	30	171	

The Following Part of the South Tropical Disturbance.

	G.M.T. h	m	○	
1915 July 28	18	48	56	
Aug. 14*	17	40	51	
Sept. 7	17	25	52	
" 10	14	41	44	
" 14	17	59	45	
" 15	13	44	42	
" 17	15	23	42	
" 22			41	
" 24	16	4	40	
Oct. 6	15	52	37	
" 14*	12	30	38	
Nov. 21	13	39	28	

	G.M.T. h	m	○	
1916 Aug. 19	17	21	310	
" 21	18	52	306	
" 29	15	25	304	
Sept. 5	16	9	303	
Oct. 4	14	59	302	

* Indicates Mr. A. F. Kohlman's observations

THE DARK SPOTS IN THE NORTHERN EQUATORIAL BELT.

1915	July	23				321	1916	Jan.	2					253		
	Sept.	9		275	298	316		Feb.	16	69						
	"	11		273	299	319		July	23					266		
	"	13	205					Aug.	5	18						360
	"	16		275	298	319		"	6				120	164		
	"	17				320		"	10			190				
	Oct.	3		264	284	308		"	15	68		103				
	"	6				315		"	16					208	237	
	"	12	67					"	17							357
	"	21				358		"	18				108	125	196	
	"	29		272	304	324		"		19					300	
	Nov.	21	94					"	20			103				
								Sept.	25	66	83					
								"	30	68	84					
								Oct.	3				101	118		
								"	5		93	107				
								"	7			105	120			
								"	23						338	
								"	26	66	82	100				
								Nov.	5						338	4
								"	6		82	108	120			
								"	8	61	86	107				

MAN AND THE UNIVERSE.

C. M. KILBY.

"What a piece of work is man! how noble in reason! how infinite in faculty! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals! And yet, what is this quintessence of dust?"

Measured by man's standards man is a mighty being, a colossus, the lord and ruler of the world, and in our younger days man seemed to be almost the lord of the universe, or at least the universe seemed to be made for him. Fortunately, as we grow older this magnification decreases until finally we see man in his true perspective—as through a telescope reversed. Then he is known to be only an infinitesimal in infinite space. He is but a speck upon a ball 8000 miles in diameter, rotating on its axis once in 24 hours, and revolving around the sun in about 365 days at the rate of 18.5 miles per second. Around this sun, which is one of the smaller and cooler stars and which appears large because it is only 93,000,000 miles from us, revolve other planets—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune, in order, whose distances from it range from 36 to 2800 million miles.

Along with this solar system of sun, planets, meteors, and comets, we speed through space at 12 miles per second, not knowing whither we go nor why. Other suns, or stars, doubtless have their planetary systems also, and all, according to our observations, are hastening through space. The unaided eye sees but 6000 of these stars, but the telescope reveals 100,000,000. The nearest one to us is 25,000,000,000,000 (25 trillion) miles distant and heaven only knows how far is the farthest. Though light travels at a rate of 186,000 miles per second, it takes about 4½ years for light to come to us from the nearest star, α Centauri, and 50 years to come from the Pole star. Therefore some of the stars we are now seeing may have been blotted out centuries ago.

Our only visitors are meteors and comets. Several hundred meteorites have actually reached the earth and been found. They are the remnants of former worlds that tell us that those worlds were composed of the same materials as our earth. Most of these intended visitors are burnt to powder by friction when they strike our atmosphere, and become but dust of our earth. Some that contain occluded gas burst with explosive violence and furnish us beautiful pyrotechnics. All are small and weigh less than 500 pounds.

The comets are more distinguished visitors, but are light airy nothings with electric tails. In passing through our solar system their orbits and motions are changed by the influence of the sun and the planets—especially Jupiter—and thus are captured for trespassing. Many of the phenomena accompanying them are optical and electrical and change as they continue on their courses.

Of all this how much does man control? Is he monarch of all he surveys? He has no voice in their motions, no power to change the course of even one meteor. He is but an onlooker, a passenger through space without chart or compass, or even steering gear. Around and 'round he goes "on the whirligig of time circling with the seasons," which cover him with their snows, bite him with their frosts, and scorch him with summer suns; and he can not lift a hand to stay them.

Though man is but a speck compared to his habitat, the earth itself is not so large. When we consider some measurements it seems not only large but immense. For instance, its surface contains 200,000,000 square miles, its volume is 260,000,000,000 (260 billion) cubic miles, and its mass is 6,600,000,000,000,000,000,000 (6,600 million million millions) tons. There are 52,000,000 square miles of land and 145,000,000 square miles of water, and living here are 1,500,000,000 persons. These numbers are large and hence our magnified idea of the size of our planet. But a square mile, a cubic mile, and a ton are all small quantities, and hence these large numbers. If it were said that

a year consists of 31,536,000 seconds, one might get the idea that a year is an aeon. And so numbers sometimes fool us.

Though the earth is 25,000 miles in circumference, it can be circled in a few days. At the now moderate speed of 60 miles per hour it would require but 17 days. Its curvature shows a drop of 8 inches in 1 mile and 64 inches in 2 miles. The lower 600 feet of a mountain only 30 miles distant are below the horizon. And so it seems that our earth is indeed a ball, and a small one at that. Its surface is nearly smooth, as its highest mountain, Everest, rises less than 6 miles above sea level, and the ocean bed is about the same distance below.

Man on his island home is a creature of circumstances. If the earth's temperature were to rise 40 or 50 degrees above, or drop as much below, the present range, he would pass away and the place thereof would know him no more. Or, if the sun's temperature were to fall as much as 14° F, a glacial period would occur and refrigerate us all. A slight change in the relative amounts of oxygen and nitrogen constituting our atmosphere would end our days. If the water were removed our bodies, which are 90% water, would soon wither away.

Why man was placed here and whither he goes—who can tell? In spite of his insignificance and impotence, he has gazed into space and explored the starry regions. He has discoved many mysteries and solved many riddles, but the First Cause and the final consummation remain unrevealed to his intellect. And so, "there is a door to which he finds no key, there is a veil through which he can not see."

But he has seen and discovered many things. With his science he has dispelled the idea that the stars and planets are divinities, that they are candles periodically lit, and shown that they are simply masses of matter. He knows that the earth is not flat and that it is supported neither by a tortoise nor by Atlas. Nor is the earth the center of the universe, nor even the center of one of the numberless systems. With the aid of his chemical balance and reagents he can say that the earth's crust contains 47% oxygen, 28% silicon, 8% aluminum, 4% iron, 0.17% hydrogen, and 0.12% carbon. With his barometer he can tell us that the atmosphere extends but 70 miles above the earth's surface. He can point his telescope to the sister planets, see, and photograph their surface marking; with his spectrometer he can tell what elemental substances constitute the sun and stars; and with his bolometer he can tell you that the temperature of the sun is 12000°F and that the moon is icy cold. With his Coulomb's balance he can weigh the earth, and with the aid of his scientific laws determine the mass of the planets and the moon, and predict eclipses. He has told us that the solar system was formerly a nebula, which by gravitation and cooling formed the sun and planets. He has pointed out 10,000 nebulae, which

slowly, but surely, are condensing to form other solar systems. He has discovered the cosmic process, evolution, a cyclic process without beginning and without end, progressive and continuous. From internal evidence he finds that the earth has reached the age of some 60,000,000 years. Though still cooling and contracting its end is in the dim and distant future. Within its surface much heat is stored, for as we dig down its temperature increases 1° F for every 70 feet. The sun, a mass 880,000 miles in diameter, has cooled more slowly and its temperature is yet 12,000° F. Through calculations it is known that the sun's heat is not due merely to cooling, for if it were its temperature would not long remain constant. As it cools, it contracts; as it contracts, its temperature is raised; and thus its heat is maintained. Another factor in this maintenance is the wonderful metal radium, which undoubtedly exists in the sun. This metal is a heat factory in itself.

Not only has he delved into the past, but he has dipped into the future and predicted discoveries of other worlds. The prediction and discovery of Neptune, the farthest known planet, is evidence of his ability and acumen.

Man's inquiries have not been limited to the inanimate matter of the universe. For centuries he has wondered whether worlds are inhabited. It was formerly thought that all of the planets, stars, moon, and sun were inhabited, but now we know that this cannot be unless their residents are far different from us.

In ancient times it was said that the heavenly bodies were round because the circle is the perfect figure. It was also thought that their motions and conditions were permanently fixed because established by a perfect creator. Though the motions and forces of the sun, earth, and moon are finely balanced, we know now that sooner or later their equilibrium will be destroyed and that the earth will be ground to pieces by the moon or fall into the sun to be destroyed by fire. Whether the earth will be refrigerated and depopulated long before such a cataclysm occurs, man cannot yet tell.

As the solar system is speeding towards the constellation Hercules, perhaps to join the cluster of 6000 stars observable there, the avoidance of a collision with other systems seems impossible. Such a collision would start another cycle in the evolutionary process. Thus one cycle follows another, but all are in the same progressive march through eternity. Was there a beginning? Man can find no evidence of it; nor can he find any promise of an end. The present stage is but a phase of the endless cosmic cycle:—condensation—collision—heating—nebulae; then condensation, collision, etc. again. The creator has not finished his work—and never will. "He is ever present, ever-working throughout the universe—an Infinite and Eternal Energy. And

"When you and I behind the veil are past,
Oh, but the long, long while the world shall last,
Which of our coming and departure heeds
As the sea's self should heed a pebble cast."

Man has not only made measurements and calculations of things seen, but has also launched his mind upon the sea of infinity to explore its unknown shores and answer the riddles that he meets. He does not balk at the question, "Is the universe infinite?" though he knows that he can not conceive of infinite space because the idea is beyond the power of his imagination. But this fact does not prevent an answer to the question. As Spencer has said, "Conceivability or non-conceivability is never proof." Man employs his reason and argues that since everything occupies space, space can be limited only by space. Therefore, it is self-limited only, and therefore endless and infinite. Again, who would deny that 1.0/3 gives an endless result, an infinity of 3's? Yet imagination can not cope with them. Thus reason attests an infinity though imagination can not reach it. Again, reason suggests that time is infinite—without beginning and without end—but mind can not grasp the idea.

So man, the quintessence of dust, is but a mote in an infinity of infinities. Though his "dim horizon is bounded by a span", he gazes intently at the passing show that comes within his ken—an onlooker who can control nothing,—one of the "magic shadow shapes that come and go 'round with the sun-illumined lantern held in midnight by the master of the show; one of the helpless pieces of the game He plays upon this checker-board of nights and days, hither and thither moves, and checks and slays, and one by one back in the closet lays."

Through infinite space he whirls in complex spiral motion at 30 miles per second, speeding on and on until his days are ended. Like the poor player upon the stage he struts and frets until his part is done. He is but a "flower of the field which today is and tomorrow is no more." "He dieth and wasteth away: yea, man giveth up the ghost, and where is he?"

THE FLASH SPECTRUM.

BERNHARD H. DAWSON.

The flash spectrum received its name from the circumstances of its first observation. Already in 1868 the protuberances had been shown to have bright line spectra, and in celebration of the observation of this fact by the two observers Lockyer and Janssen, working independently, the Paris Academy caused a medal to be struck. But the result was not what had been expected, for the astrophysicists had expected that according to Kirchhoff's law all the Fraunhofer lines would be seen as bright lines, while in reality only a dozen or so lines were seen bright. Not until the eclipse of 1870 was the discrepancy explained. At this eclipse, by watching the place where the chromosphere should be, as the moon approached the edge of the sun's disk and cut off the last photospheric rays, Young saw a bright-line reversal of the Fraunhofer spectrum flash into view. From this occurrence the name has arisen. In 1896 Shackleton and Lockyer succeeded in photographing this phenomenon with prismatic cameras, and since that date hardly an eclipse has passed at which some photographs of it have not been secured.

This phenomenon is observable only at the times of second and third contact. During the remainder of totality the moon covers the chromosphere as well as the photosphere, and only the protuberances and the corona are visible. It is not, however, absolutely instantaneous. The estimates of its duration varied in the seventies from less than an eighth of a second to seven seconds. At the beginning of totality the stronger lines appear first, then as the photospheric light is cut out more and more, the weaker lines appear in succession until at the very first instant of real totality the faintest lines are shown just for a moment and almost immediately cut out again as the moon obscures the level at which they arise. Then, as the moon advances, the lines of successively higher level are cut out, the dozen or so strongest lines remaining for several seconds. The lines of hydrogen, helium and calcium can be seen the longest, both before totality on account of their greater intensity and after totality has begun on account of the high level to which the vapors producing them arise. The same is true in the reverse order at third contact. The majority of the lines have a duration of about two seconds, but this duration is different for different lines, and for the faintest is but a fraction of a second.

This bright line or flash spectrum is in general a reversal of the Fraunhofer spectrum. Mitchell, in his observations in 1905, obtained plates from which he measured the wave lengths of nearly three thousand lines, of which only 126 were not identified with lines in Rowland's map of the Fraunhofer spectrum. But there are many significant differences. Many of the weakest Fraunhofer lines do not appear at all. This is of course easily explicable by the very fact of their faintness, the short exposure time not being sufficient for them to impress themselves. Almost every line having an intensity of three or greater on Rowland's scale in the Fraunhofer spectrum is present in the flash spectrum as well. The greatest difference is in the relative intensities of the lines of the different elements. Perhaps the most striking example is helium, which is not present at all in the ordinary Fraunhofer spectrum but has some of the strongest lines in the flash. As far as any general rule can be stated, it seems that the elements of great atomic weight are relatively weak in the chromosphere, while calcium and the two lightest, hydrogen and helium, are the strongest. When we come to consider the elements individually we see another difference. It is almost universally true that the "enhanced" lines in the spectrum of the element are stronger in proportion to the others. It is consequently more like the spark spectrum, while the Fraunhofer spectrum resembles the arc spectrum. As an explanation of the relative increase in brightness of enhanced lines, Mitchell says "The vapors forming the enhanced lines ascend to relatively high altitudes, from which results a decrease in pressure and a mixing with hydrogen, and * * * on account of height, reduced pressure and the presence of hydrogen, the enhanced lines become very strong." Another point of interest is that if the periodic table of the chemical elements be taken and those elements be marked which are present in the flash, no one of them will be found to be entirely isolated, and in general they group themselves around calcium, which has the strongest lines.

While a deeper understanding of the conditions necessary to the successful observation of the flash spectrum has of course resulted in a continuous improvement of the instruments and methods of observing, the greatest advances after the photographic plate was introduced, have probably been the substitution of the objective grating for the objective prism, and the observation of the flash spectrum without eclipse. In all the observations at eclipses no slit is used, because the moon, in cutting out all the photospheric light, leaves only the thin crescent of the chromosphere and reversing layer which is itself as good as a slit, and even better under the conditions, because the introduction of a slit would so cut down the total light as to increase the

necessary length of exposure beyond the duration of the flash. The observation of the chromospheric spectrum without eclipse, on the other hand, necessitates high dispersion and a narrow slit, in order to cut down the intensity of the continuous spectrum of the photospheric light reflected from the earth's atmosphere. It required the powerful instruments of the Mount Wilson Observatory to get results of any scientific value from this method. Its great advantage lies in the fact that, with the use of a slit and high dispersion, wave lengths can be very accurately measured and the results will be free from the uncertainties arising from the curved form and uncertain upper boundary of the lines in the objective prism or objective grating plates taken at eclipses. In spite of the statement made by Mitchell that "the wave lengths have about an equal accuracy," those from the Mount Wilson plates have probable errors only six tenths as great as those by him. He also says that the spectrum without eclipse does not reach to as low a level as the eclipse spectra he obtained. St. John says that Mitchell reached to far lower levels than other eclipse observers, but his remarks indicate that he believes on good ground that the Hale-Adams spectra reach to a yet lower level.

The scientific results obtained from flash spectra are various in character. The first important result was the verification of Kirchhoff's law in its qualitative aspects. The results here are of special value because in comparing the Fraunhofer and flash spectra we are comparing absorption and emission under the same conditions of temperature and pressure, a circumstance difficult to obtain in the laboratory. In the light of later investigations and results it seems that the quantitative relations of the law are also largely satisfied. This conclusion is borne up by and used in the determination of the distribution of the elements in the chromosphere. From the fact that the wave lengths of the flash lines are certainly not systematically displaced from those of the dark lines of the ordinary spectrum by so much as 0.01Å, and probably not as much as 0.002Å, we have strong evidence against the hypothesis of Julius that these lines are produced by anomalous dispersion. An interesting result is that the principal coronal line was not observed, thus showing that the intensity of that line does not greatly increase towards the sun's edge.

Another result of considerable interest and some importance is that we find here conditions which transcend laboratory conditions, but only so little that the relation between emission and absorption can still be interpreted on the basis of laboratory results. Most of the elements under consideration can be made to give emission spectra in the laboratory, while but few of them can be made to absorb selectively. Sodium is probably the easiest. Here in the flash spectrum we have emission

spectra most of which have corresponding absorption in the Fraunhofer spectrum, and hence we can conclude that under solar conditions these elements both emit and absorb selectively. But there are some emission lines, notably those of helium, which have no counterparts in the Fraunhofer spectrum. It seems then that helium is not absorptive even under solar conditions. To find it absorptively active we must go to the stars with Class B spectra for examples. It is interesting to note in this connection that "chromospheric" lines are present as bright lines in the spectra of ϕ Persei, γ Cassiopeiae and several other bright line stars of Class B, and as absorption in α Cygni and others.

But by far the most important result from the flash spectrum is the knowledge that we obtain through it about the nature of the chromosphere and reversing layer and the distribution of elements in them. From the fact that the chromosphere gives a bright line spectrum we can at once conclude that it is gaseous and make a chemical analysis of it. From the fact that not all the lines nor even a majority of them have the same upper limit we conclude that the reversing layer is not distinctly separate from the rest of the chromosphere, but can be considered of different depths as we consider different elements. These conclusions about the different heights to which the various elements reach are easily obtained qualitatively. For a quantitative determination several methods, using different classes of data, have been devised. The first, used by Mitchell, is based upon the measurement of the lengths of the arcs of the bright lines in the eclipse flash. The theory of this is very simple. In a total eclipse the moon's augmented semidiameter is greater than that of the sun and consequently at second and third contacts the moon's disk will overreach the boundary of the photosphere more and more as we recede from the point of contact. This overreaching can be accurately computed, and the value corresponding to any measured length of arc of a bright line will give directly the height to which the element under consideration extends. The chief uncertainties arise from the irregularity of the moon's limb, the presence of prominences and the diffuse character of some of the lines and the consequent difficulty of determining just how far they extend. In this last we are helped somewhat by the fact that the higher the line extends, the longer its exposure time will be. When the strong lines are really higher, as seems in general to be the case, this fact helps us greatly in the other method of discussion of eclipse spectra, namely the comparison of flash intensities with solar. In this discussion the enhanced lines and the ordinary lines must be considered separately. As the ordinary lines outnumber the enhanced lines, the greater part of the result depends on them. The observed intensities, when tabulated according to the intensity in the Fraunhofer spectrum, show a systematic difference, the weaker lines being relatively stronger in the

flash than in the Fraunhofer spectrum, while the stronger lines are not as strong in proportion to the weaker ones as in the Fraunhofer spectrum. The interpretation placed on this is that the weaker lines are lines originating at lower levels in the reversing layer; the gases there being hotter causes them to radiate nearly as strongly as their absorption, thus making the solar intensity weak, but the flash intensity relatively stronger. The lines that are stronger in the sun, however, are due to layers lying higher, and consequently relatively cool, thus emitting only a small amount of light in comparison to what they absorb and showing up strongly in the Fraunhofer spectrum but relatively weaker in the flash. In a consideration of these data the enhanced lines show an anomaly in having greater intensity in the flash than other lines of the same solar intensity, and yet from other considerations seeming to be higher. The fact that they do appear higher and that at the same time the other lines compared among themselves indicate a lower temperature in the higher layers appears to be strong evidence that their greater brightness in the spark is not (at least not necessarily) due to higher temperature in the spark than in the arc. Another point of interest is that when lines of equal solar intensity are compared among themselves, those in the violet end of the spectrum seem to come from higher levels than those in the red end.

Confirmatory evidence and conclusions parallel to all these have been deduced from spectra at other times than eclipse. In the flash spectrum without eclipse it was necessrry to have a large image of the sun, in order that low levels might be reached without letting in direct photospheric light, before the fainter lines could be observed. This is directly confirmatory of the conclusion that fainter lines arise at lower levels. From radial displacement work in the study of sunspot vortices data were obtained which, when interpreted on the basis of St. John's conclusions from that work, point to conclusions entirely in accord with the foregoing. With this confirmation it is safe to accept his conclusion that "The resulting distribution shows that the H_3 and K_3 lines of calcium are the lines of highest level, followed by the $H\alpha$ line of hydrogen, and that, in the main, the heavy and rare elements occur in detectable amounts only in the lower portions of the solar atmosphere." The thickness of this lower portion, usually called the reversing layer, would seem to be in the order of 100 km.

We have thus the flash, or chromospheric, spectrum, first observable only visually at an eclipse, now photographed even without an eclipse; giving us valuable evidence in confirmation of Kirchhoff's law and showing the Fraunhofer lines to be almost certainly due to absorption and not to anomalous refraction; suggesting that in some respects the

sun is intermediate between laboratory conditions and those existing in stars with Class B spectra; indicating that the spark is not necessarily hotter than the arc, and not only telling us what elements are present in the chromosphere, but giving us as well a pretty definite idea of their distribution in it.

Ann Arbor, Mich.
1916, March 4.

THE TOTAL SOLAR ECLIPSE OF JUNE 8, 1918

EDISON PETTIT.

On account of the favorable circumstances of the event the total solar eclipse of June 8, 1918 will be more widely observed in this country than any heretofore. The total path length is greater than that of any eclipse seen in the United States since the eclipse of 1865 and covers more available territory than either that eclipse or the eclipses of 1878 or 1900.

It is interesting to note in this connection that this is a return of the eclipse of May 28, 1900. The length of the Saros as determined by the ancient Chaldeans was 18 years 11⅓ days (10⅓ days if five leap years had intervened). Now the eclipse of May 28, 1900 occurred about 8:00 a. m. If 18 years 11⅓ days be added to this it is easily seen how it may be expected to return at 4:00 p. m. on the 8th of June, 1918. As a matter of fact a strict calculation will throw this in doubt only a matter of some minutes. The duration of totality in this eclipse is about the same as that of 1900, viz. a minute and a half. In the map the heavy underlined figures give the duration of totality as seen on the central line of the track in minutes and seconds, the light underlined figures are the standard times of the beginning of the total phase for the corresponding points in the central path. Under the latter will be found the Sun's altitude. The per cent of totality is given for various cities not on the eclipse track. To find the per cent of the eclipse for any place not on the map deduct one per cent for every 30 miles the place is from the middle line of the eclipse track. Thus Lincoln, Nebraska, is 300 miles from the middle of the track, hence the per cent of totality is 90.

The eclipse begins when the moon's shadow strikes the earth on the little island of Borodino off the coast of Japan at sunrise, June 9, 1918. It will then sweep eastward and after the lapse of 2 hrs 15 min. will arrive at the mouth of the Columbia river in Washington State June 8,

at 2:55 p. m., Pacific time. It is then going at a speed of 33 miles a minute. It then strikes south-east, will pass the Mississippi river at 5:37 Central time and leave the coast of Florida at 6:42, Eastern time. Three minutes later it will be lost in the sunset 400 miles at sea. It will require only 47 minutes to travel the entire diagonal distance from coast to coast.

The long path traversed in the United States, over well settled country makes the following scheme of coöperation seem to be not out of the bounds of possibility. Suppose an eclipse party be stationed in Washington State and another in Mississippi. Now it will be half an hour after the Washington State party sees the eclipse before it will be seen by the party in Mississippi, on account of the time it takes for the shadow to travel the enormous distance, notwithstanding its speed. Now suppose the Washington party discover what they believe to be an inter-mercurial planet. They can telegraph ahead either by cable or the wireless to the party in Mississippi and give them the details of the discovery. Thus when the eclipse reaches the Mississippi party they will be armed with the information necessary to verify the discovery. A distribution of three or four parties thus along the eclipse path will enhance the coöperative scheme.

The map shows some 85 towns on the direct route of the eclipse all of which are available to travelers by rail. The original map is blue-printed on paper 24 by 30 inches and is being printed in blue line for us by the Sante Fe R. R. and may be had by observatories and amateurs on application to this Observatory.

Washburn College Observatory.
Topeka, Kan.

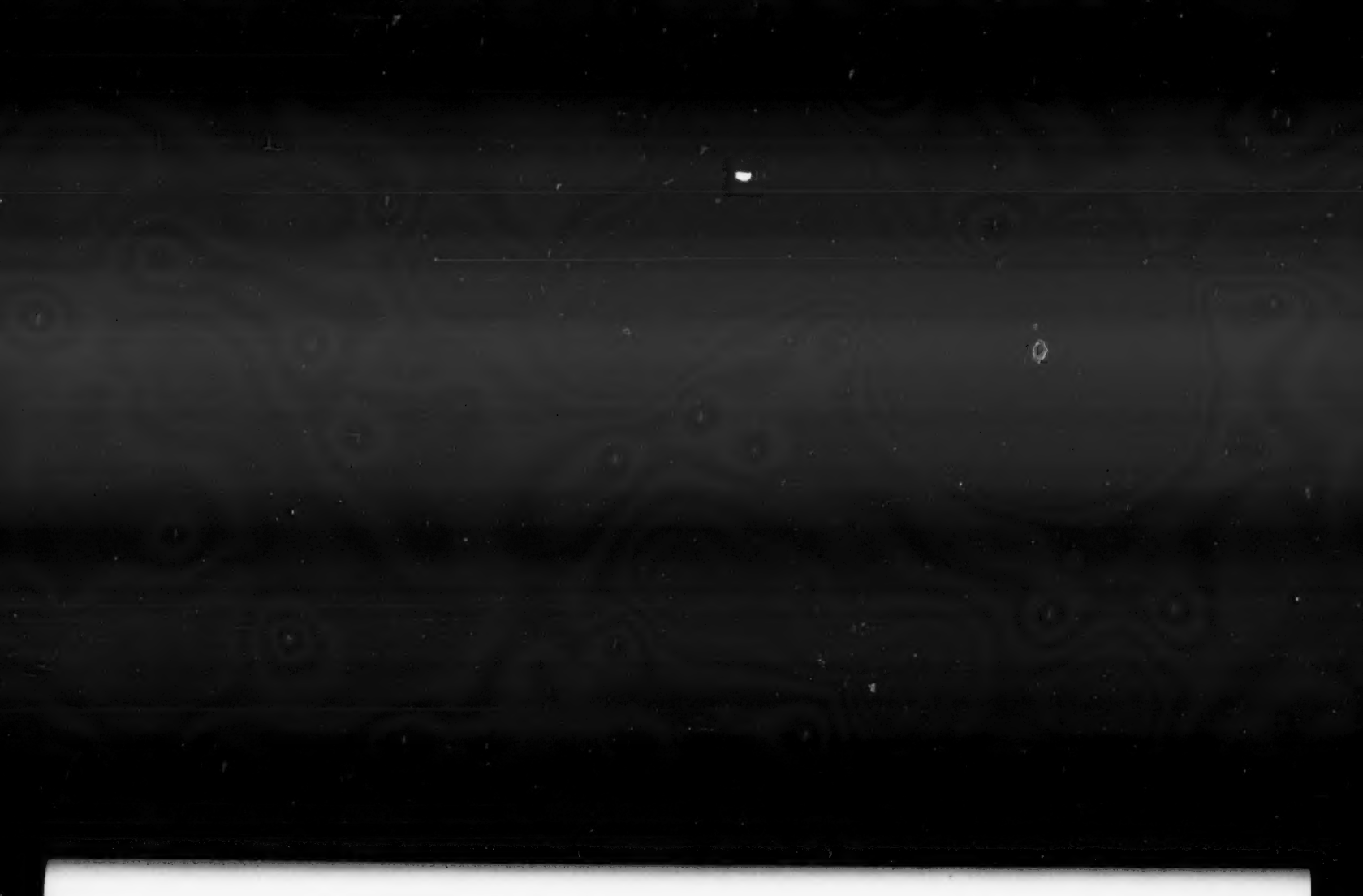
THE SOLITARY STAR.

The inky "Coal-sack" in the sky,
Is guarded by one lonely star.
The Milky Way goes dashing by,
And still, I wonder what you are!

Do other worlds lie beyond in space,
And glitter like our planets here?
Are you the guardian of the place,
And watch the portals that are near?

What lies beyond that inky bar?
No telescope has looked within,
The twinkling light of one lone star,
Helps swell creation's Hymn.

MAUD B. HUNT.



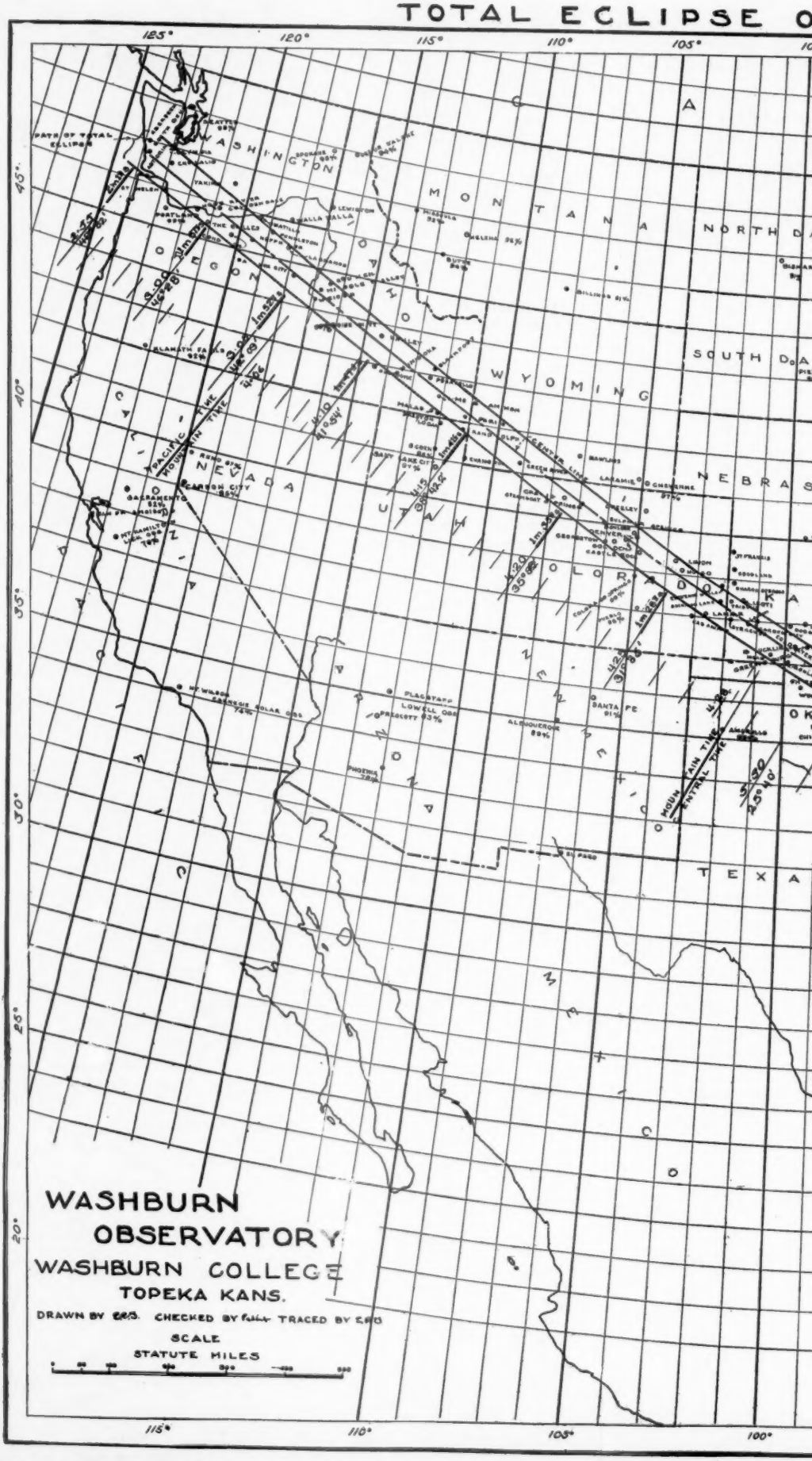
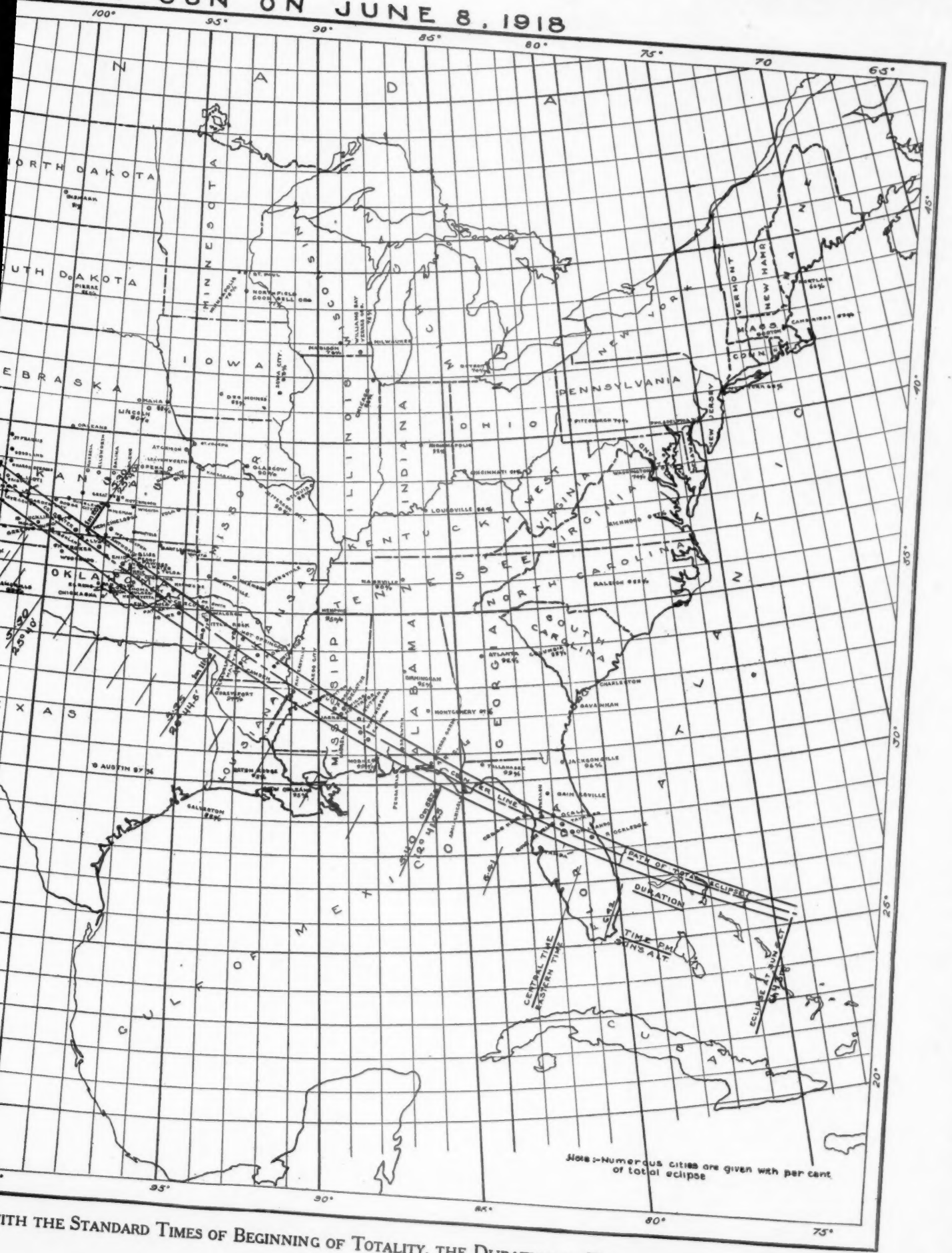


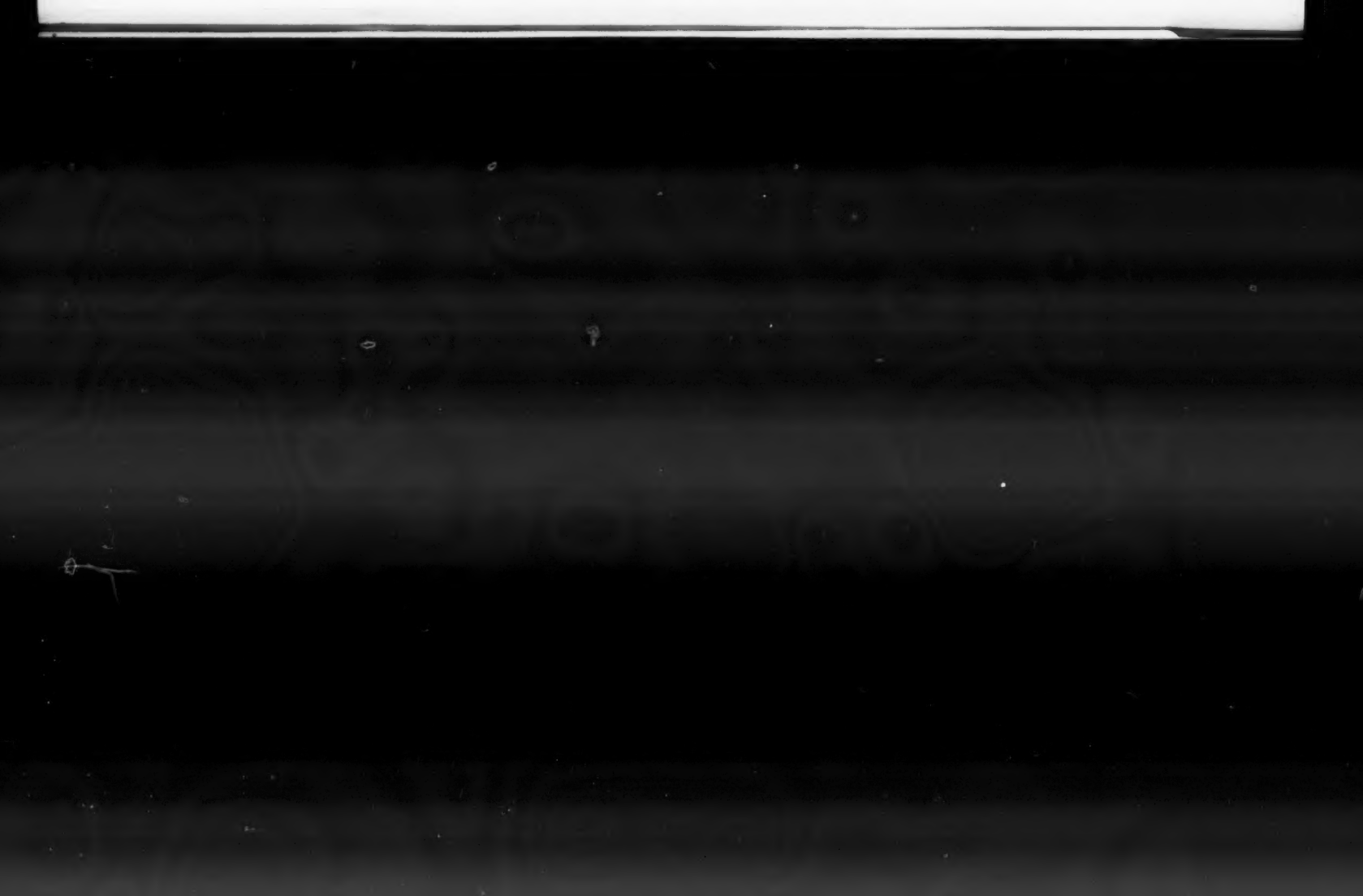
DIAGRAM SHOWING THE PATH OF THE MOON'S SHADOW ACROSS THE UNITED STATES, WITH

PLATE II.

SE OF SUN ON JUNE 8, 1918



ITH THE STANDARD TIMES OF BEGINNING OF TOTALITY, THE DURATION OF TOTALITY AND ALTITUDE OF THE SUN.

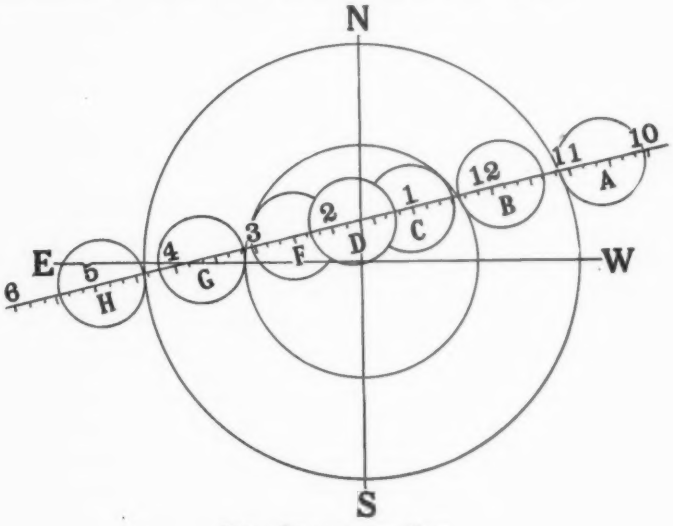


TOTAL ECLIPSE OF THE MOON, JANUARY 7-8, 1917.

WILLIAM F. RIGGE

On the night of January 7-8 there will be a total eclipse of the Moon visible all over the United States. The accompanying diagram will give us the details.

The largest circle is the cross-section of the Earth's penumbra, and the next in size is that of its shadow, at the place where the Moon will cross them. N S E W are the cardinal points. N is exactly on top when the Moon is on the meridian, but inclines to the left before that and to the right after it. The degree of this inclination depends upon the latitude of the place of observation as well as upon the hour angle of the Moon, so that it cannot be indicated on the diagram.



TOTAL ECLIPSE OF THE MOON.
JANUARY 7-8 1917.
CENTRAL TIME.

A—Moon enters Penumbra	10:36	P. M.
B—Moon enters Shadow	11:50	P. M.
C—Total Eclipse begins	1:00	A. M.
D—Middle of Eclipse	1:45	
F—Total Eclipse ends	2:29	
G—Moon leaves Shadow	3:39	
H—Moon leaves Penumbra	4:53	A. M.

Magnitude 1.37

The seven equal small circles represent the Moon at as many important moments. When its centre is at A, at 10:36 p.m., central time, the Moon enters penumbra. At B, at 11:50 p.m., the Moon enters Shadow. There is no difficulty in knowing where the point of contact will be on the Moon, since long before that time the part of the disk nearest the shadow will be noticeably darker than the rest of the Moon. At C, at 1:00 a.m. the Total Eclipse begins. At D, at 1:45 we have the Middle of the Eclipse. At F, at 2:29 the Total eclipse ends. At G, at 3:39 the Moon leaves the shadow and at H, at 4:53 the Moon leaves penumbra.

The magnitude of the eclipse is 1.37, that is, the moon's diameter might be increased 37 per cent and the eclipse would still be total.

The visibility of the Moon during totality cannot be predicted, since that depends upon the cloudy or clear condition of the skies all along the earth's sunrise and sunset circle at the time, through which the Sun's rays are refracted into the Earth's shadow.

WILLIAM HERSCHEL.

CHARLES NEVERS HOLMES.

On November 15, 1738, William Herschel, the fourth child of Isaac Herschel's family of ten children, was born at Hanover. Isaac Herschel was an excellent musician but not a famous one; and his son William was far more successful in that profession. At the age of fourteen William Herschel could perform very well both on the oboe and the viol, becoming later a member of the band of the Hanoverian Guards. In 1756, at the beginning of the Seven Years' War, a French army invaded Hanover and overwhelmed the Hanoverian Guards in the battle of Hastenbeck. William Herschel was in this battle and although not wounded the experience was so disagreeable that he deserted from the Guards. He had the good fortune to get away without being arrested and reached England, where at first he had difficulty in finding employment.

Nevertheless he did not leave England and in his 22nd year he was appointed instructor of music to the Durham militia. Shortly afterwards he received a better appointment, that of organist of the parish church at Halifax, and in 1766 he became organist of the Octagon Chapel at Bath. Bath was a fashionable resort and Herschel began to

be well known as a musician. During Sundays he played his organ, and during the rest of the week he gave lessons to many pupils as well as preparing for his concerts and oratorios. His musical career was at this time a very busy and active one.

But William Herschel had not yet found his true profession. He was naturally a deep student, and during his study of the more difficult parts of the theory of music he took up mathematics. Becoming interested in mathematics for itself, he soon turned his attention to the science of optics and after that to the telescope and finally astronomy. Using a small telescope borrowed from a friend, Herschel began his observations of the star-lighted firmament; but the instrument did not satisfy him, and he wrote a well-known optician in London, inquiring the price of a larger glass. But the price quoted by the optician was more than Herschel thought he could afford. As a result he decided to make a telescope for himself.

Most of his time was taken up by his musical profession; but henceforth every spare moment was employed in making a telescope. And the telescope that Herschel finally completed was the best and largest one in the whole world. It was of the type known as a *reflector*, being a mirror at the bottom of a tube down which the observer looked which reflected the light from the stars to him. Herschel's mirror was composed of a mixture of two parts copper and one part tin, making a very hard substance not easy to shape correctly but capable of a high polish. In 1774, in his thirty-sixth year, he had his first view of the starry firmament through his own telescope, a small instrument compared with those which he made afterwards. And although he became so famous as an astronomer he was also famous as a telescope maker, from which occupation he received a considerable financial reward. It is said that he constructed some eighty large telescopes and many smaller ones.

There was another member of the Herschel family, his sister Caroline, who also became famous in astronomy. She had left Hanover and had come to Bath to take care of her brother's house. Caroline greatly loved and admired her brother William, and this love and admiration for him caused her to take an interest in astronomy Her interest in this science increased rapidly and she was of most valuable assistance to him. She aided in grinding lenses and polishing the mirrors; and sitting beside him as he studied the darkened heavens she wrote down his astronomical observations as he uttered them. Summer and winter this went on without interruption, and often Herschel would study the stars all night, either from the small garden at the back of his house or from the street in front of his home. An all night's study of the firmament in winter time is rather cold work, and Caroline Her-

schel said that occasionally she had to give up taking notes of her brother's observations because the ink would freeze in her pen! On the following day, while William Herschel was attending to his musical profession, his sister would tabulate and arrange carefully the astronomical records of the night before and make the necessary preparations for the next night.

For several years Herschel, despite all his labor, made no important astronomical discovery. However, all this time he was gaining in experience and becoming better and better acquainted with the stars. Moreover, he had now constructed an excellent telescope and with it commenced a more methodical study of the skies. He adopted a systematic plan of observing closely all stars which were above a certain magnitude. It is not known exactly what object Herschel had in mind when he began such a systematic plan; it may have been merely in accordance with his thorough, methodical nature. However it was, hundreds and probably thousands of stars were thus examined by him. On the night of March 13, 1781, he was carefully observing a part of the constellation Gemini, and in that firmamental region discerned a star which seemed to be somewhat different from the other stars around it. For the other stars possessed no disc, no visible surface, they were merely so much more or less sparkling light. But this particular star in Gemini possessed a disc. It was by no means a new star. Other astronomers had seen it and measured its place in the firmament. But their telescopes were not as strong as the *reflector* used by Herschel. Yet this was only a part of the reason why a great discovery was made. The eye of one of earth's greatest astronomers studied that star and perceived the difference between it and the other stars in Gemini.

It was not a regular star, and Herschel observed it night after night. Presently he saw that it had slightly changed its position with relation to some of the other stars close by—that it was not a "fixed star". Therefore, at first, although he believed that this body belonged to our solar system, he thought it was simply a comet. Of course it took time to prove that it was not a comet and to discover the true character of this peculiar star. After the necessary observations and calculations had carefully been made, the truth respecting it was discovered—this wandering star with the tiny disc was no less a firmamental object than another planet!

Until that time man had known only six planets in the solar system —Mercury, Venus, Earth, Mars, Jupiter and Saturn. He had seen, shining more or less brightly in the darkened sky, only five planets. These five planets he had admired and studied from pre-historic times. But here was a sixth planet in the starry firmament, so far remote as

to be almost invisible to the unassisted sight. Of course we all know that this sixth planet is called Uranus; but what we do not so often remember is that Uranus was the first planet to have its discovery recorded. There is and can be no record of the time when Mercury, Venus, Mars, Jupiter or Saturn was discovered by some early star-gazer, whereas in the case of Uranus or Neptune the date of such discovery was published. Therefore, Sir William Herschel was the first astronomer who is known to have discovered a planet. Later, Adams and LeVerrier calculated the position of Neptune; but William Herschel was the pioneer in finding a planet.

It was indeed a remarkable achievement. It is trus that Uranus is not a popular planet, for it is not conspicuous amid the stars of night and public attention is not often called to it as in the case of Mars or Venus. But, nevertheless, to astronomers Uranus is very important. It is approximately twice as far from us as Saturn and its "year" is more than 30,000 days long. Its orbital velocity is about four miles per second, which seems comparatively slow compared with that of our earth. Its size or volume is 65 times that of our own planet, its mean diameter being about 32,000 miles compared with the terrestrial mean diameter of 7,917.6 miles. The mass of Uranus approximates fifteen times the terrestrial mass, its density only 0.22 that of our earth 1.22 that of water. With respect to surface gravity, Uranus has an attraction almost equal to that of our World, nine-tenths; and is well known this distant planet possesses four moons while our earth has only one. These four satellites of Uranus are named Ariel, Umbriel, Titania and Oberon; Titania and Oberon being discovered by Herschel in 1787 and Ariel and Umbriel by Lassell in 1851. The mean distances of these satellites from their planets are: Ariel 120,000 miles, Umbriel 167,000 miles, Titania 273,000 miles, and Oberon 365,000. Of course, another satellite may be found at any time; but as far as we know Uranus possesses only four moons.

Although Herschel discerned through his 7-inch reflector that a certain star in Gemini was different from the other stars around it, the fact that it was a planet and not a comet, revolving in an orbit outside of Saturn, was not proved until nearly a year afterwards when Lexell of Russia had calculated its firmamental motion. The announcement by Herschel that this star was different from the others caused a profound sensation all over England as well as in other countries, and when King George the Third heard about it he summoned its discoverer to his Court. When Herschel came he brought with him a telescope, also a chart of the solar system, and succeeded in greatly interesting the King not only in Uranus but also in its discoverer. Indeed his Majesty took a strong liking to William Herschel, and appointed him

astronomer-royal with a salary of £200 a year, provided him with a residence at Slough, near the castle at Windsor, and furnished him with funds to construct large telescopes. The King did not forget Herschel's sister Caroline, to whom he gave a salary, appointing her to the position of her brother's assistant.

Herschel now gave up entirely his musical profession. For more than thirty years afterwards he and his sister continued energetically their astronomical labors. But although he accomplished still more in his scientific profession, the discovery of Uranus was his greatest achievement. He sent many communications to the Royal Society with respect to double stars, nebulae and clusters. In 1783 he wrote his book on "Motion of the Solar System in Space" and also a paper, "On the Places of 145 New Double Stars." As has been stated, Herschel discovered two of the satellites of Uranus, and he also found two of the moons of Saturn, Mimas and Enceladus, the nearest of the satellites to that planet. Herschel discovered, also, the rotation of Saturn's rings, the rotation periods of Saturn and Venus, binary stars, the constitution of nebulae and a good deal respecting the remote Milky Way. In 1789 he completed his most famous telescope which had a focal length of forty feet.

William Herschel married somewhat late in life; and his only son, afterwards Sir John Herschel, was also a famous astronomer. Sir John Frederick William Herschel, however, did not accomplish as much astronomically as Sir William Herschel. The older, more famous Herschel died in 1822, and after his death his sister Caroline returned to Hanover, her birthplace. Here Caroline Herschel lived for many years. She died in 1848.

It is certainly a remarkable record, three famous astronomers in one family, William, John and Caroline Herschel. But the greatest of these was William Herschel. Notable as a musician, he became illustrious as an astronomer. The planet Uranus will always be associated with his name, and from the orbital deviations of that planet Adams and Leverrier discovered the presence of our outer planet Neptune. Doubtless, Uranus, or Herschel, as it was once called, would have been found before long by some astronomer with a strong telescope and discerning eyesight; but the sooner that such discoveries are made the better it is for science and mankind. Accordingly, great credit and renown should be accorded to William Herschel. He was certainly a true and progressive pioneer among the earlier unknown regions of the illimitable Universe.

Newton, Mass.
41 Arlington St.

NINETEENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

[*Continued from Vol. 24, page 670.*]

STELLAR PARALLAXES DETERMINED BY PHOTOGRAPHY AT THE LEANDER McCORMICK OBSERVATORY.

By S. A. Mitchell assisted by C. P. Olivier, H. L. Alden, P. H. Graham, and R. C. Lamb.

A detailed account of the work bearing the above title will shortly appear. This will be published by Columbia University as an Ernest Kempton Adams research.

The photographs were made with the 26-inch refractor using a color-filter and 5x7 isochromatic plates. The methods of exposure, measurement, and reduction were substantially the same as those explained by Schlesinger, and by Slocum and Mitchell in the *Astrophysical Journal* in Vols. 32, 33, 34, and 38. Mrs. A. L. Hall-Quest rendered very efficient aid in the reductions.

The average probable error in the determination of the parallax amounts to slightly less than 0″.010.

Star	R.A. 1900	Decl. 1900	Magnitude and Spectrum	Proper Motion	Relative Parallax	Probable Error	Measured by
	h m	° ′		″	″	″	
α Cassiopeiae	0 35	55 59	Var K	0.06	0.025	±0.005	M
β Andromedae	1 4	35 5	2.4 Ma	0.22	0.058	0.008	Ol
ω Andromedae	1 22	44 53	5.0 F5	0.36	0.023	0.010	A
η Piscium	1 26	14 50	3.7 G5	0.03	0.051	0.009	Ol
ο Ceti	2 14	− 3 25	Var Md	0.24	0.061	0.007	M
γ Ceti	2 38	2 48	3.6 A	0.21	0.037	0.008	M
α Ceti	2 57	3 42	2.8 Ma	0.08	0.017	0.010	A
ρ Persei	2 59	38 27	Var G	0.18	0.029	0.009	L
43 Tauri	4 4	19 24	5.7 G	0.09	0.019	0.012	A
40 Eridani A	4 10	− 7 48	4.5 G5	2.22	0.194	0.009	M
40 Eridani B	4 10	− 7 48	9.1	2.2	0.214	0.008	M
ξ Eridani	4 18	− 3 58	5.2 A?	0.07	0.010	0.009	A
π^3 Orionis	4 44	6 47	3.3 F8	0.47	0.151	0.009	M
A. G. Leip. 1819	4 44	6 46	8.5		−0.020	0.015	M
γ Leporis A	5 40	−22 27	3.8 F8	0.47	0.103	0.010	M
γ Leporis B	5 40	−22 29	6.9	0.47	0.140	0.007	M
δ Aurigae	5 51	54 16	3.9 K	0.15	−0.015	0.008	A
η Geminorum	6 8	22 32	Var Ma	0.06	−0.011	0.011	Ol
β Canis Majoris	6 18	−17 54	2.0 B	0.01	0.009	0.009	M
ξ Geminorum	6 40	13 0	3.4 F5	0.23	0.037	0.007	Ol

Star	R.A. 1900	Decl. 1900	Magnitude and Spectrum	Proper Motion	Relative Parallax	Probable Error	Measured by
	h m	° ′		″	″	″	
Monocerotis 97	6 47	— 0 26	5.8 A	0.2	0.035	0.009	A
ι Geminorum	7 19	27 59	3.9 K	0.12	0.008	0.006	A
Procyon	7 34	5 28	0.5 F5	1.22	0.309	0.007	M
α Monocerotis	7 36	— 9 19	4.1 K	0.08	0.000	0.011	A
β Cancri	8 11	9 30	3.8 K2	0.08	—0.005	0.005	Ol
δ Cancri	8 39	18 31	4.2 K	0.24	0.048	0.010	Ol
o Leonis	9 36	10 20	3.8 F5	0.15	0.029	0.012	A
χ Leonis	11 0	7 53	4.7 F	0.35	0.007	0.010	Ol
93 Leonis	11 43	20 46	4.5 F8	0.16	0.019	0.010	G
β Virginis	11 45	2 19	3.8 F8	0.97	0.110	0.010	M
ξ Bootis	14 47	19 31	4.6 K5	0.17	0.225	0.015	Ol
Lal. 27173 A	14 51	—20 58	5.8 K	2.06	0.172	0.010	M
Lal. 27173 B	14 51	—20 58	7.3	2.01	0.206	0.005	M
β Serpentis	15 41	15 44	3.7 A2	0.09	0.054	0.005	M
γ Serpentis	15 51	15 59	3.9 F8	1.34	0.098	0.008	A
ν Scorpii A	16 6	—19 12	4.3 B	0.03	0.010	0.010	M
ν Scorpii B	16 6	—19 12	6.5 B	0.03	0.042	0.015	M
η Draconis	16 23	61 41	2.9 G5	0.06	0.002	0.010	A
70 Ophiuchi A	18 0	2 30	4.1 K	1.15	0.145	0.007	M
70 Ophiuchi B	18 0	2 30	6.1 K	1.15	0.165	0.007	M
γ Draconis	17 54	51 30	2.4 K5	0.03	0.006	0.011	Ol
110 Herculis	18 41	20 27	4.3 F5	0.35	0.076	0.008	A
χ Draconis	18 22	72 42	3.7 F8	0.63	0.090	0.011	Ol
ζ Aquilae	19 0	13 43	3.0 A	0.10	0.027	0.010	Ol
Lal. 36074	19 6	16 41	7.5	0.22	0.016	0.011	M
Lal. 36081	19 6	16 41	6.4 A	0.03	—0.004	0.008	M
Σ 2481 A	19 8	38 37	8.0	0.27	0.019	0.010	M
Σ 2481 B = Se 2	19 8	38 37	8.0	0.27	0.046	0.011	M
Σ 2486 A	19 9	49 40	6.6 G3	0.63	0.051	0.006	M
Σ 2486 B	19 9	49 40	6.8 G3	0.63	0.036	0.007	M
β_1 Cygni	19 26	27 44	3.2	0.01	—0.006	0.010	Ol
β_2 Cygni	19 26	27 44	5.4 Kp	0.01	0.000	0.007	Ol
θ Cygni	19 33	49 59	4.6 F5	0.25	0.080	0.011	Ol
α Sagittae	19 36	17 47	4.4 G	0.04	—0.035	0.007	G
β G. C. 9602	19 42	33 23	7.5	0.45	0.037	0.011	M
17 Cygni A	19 43	33 30	5.1 F5	0.45	0.080	0.012	M
17 Cygni B	19 43	33 30	8.1	0.45	0.046	0.008	M
Altair	19 46	8 36	1.2 A5	0.64	0.218	0.007	M
η Aquilae	19 47	0 45	Var G	0.01	0.001	0.009	A
β Aquilae	19 50	6 9	3.9 K	0.48	0.066	0.011	M
α_1 Capricorni	20 12	—12 49	4.6 G	0.02	—0.017	0.009	Ol
α_2 Capricorni	20 12	—12 51	3.8 K0	0.06	—0.017	0.013	Ol
β Capricorni A	20 15	—15 6	3.2 Gp	0.04	0.002	0.008	M
β Capricorni B	20 15	—15 6	6.2 A	0.04	0.000	0.010	M
γ Delphini A	20 42	15 46	4.5 G5	0.20	0.071	0.009	M
γ Delphini B	20 42	15 46	5.5 G5	0.20	0.063	0.009	M
ε Cygni	20 42	33 35	2.6 K2	0.48	0.034	0.015	G
o^1 Cygni	20 10	46 30	5.0 A2	0.01	0.022	0.009	A
o^2 Cygni	20 10	46 26	4.0 Kp	0.00	—0.002	0.013	A
β Delphini	20 32	14 15	3.7 F5	0.12	0.008	0.008	Ol
ε Equulei A	20 54	3 55	5.3 F5	0.19	0.043	0.010	M
ε Equulei B	20 54	3 55	7.4	0.19	0.002	0.012	M
ζ Cygni	21 9	29 49	3.4 K	0.06	0.043	0.015	A
γ Capricorni	21 35	—17 7	3.8 Fp	0.19	0.013	0.009	Ol
76 Cygni	21 37	40 21	6.0 A	0.06	0.006	0.010	A

Star	R.A. 1900	Decl. 1900	Magnitude and Spectrum	Proper Motion	Relative Parallax	Probable Error	Measured by
	h m	° ′		″	″	″	
μ Cygni	21 39	28 17	4.7 F5	0.37	0.041	0.010	M
κ Pegasi	21 40	25 11	4.3 F5	0.03	0.007	0.006	G
α Aquarii	22 0	— 0 48	3.2 G	0.01	0.005	0.010	M
ι Pegasi	22 2	24 51	4.0 F5	0.30	0.120	0.007	Ol
ι Cephei	22 46	65 40	3.7 K	0.14	0.031	0.008	A
Lal. 45028	22 56	— 4 23	7.8 K2	0.54	0.053	0.011	Ol
β 182	23 12	—14 22	8.2 A2	1.31	0.024	0.006	M
Lal. 45638	23 13	4 52	8.5 G8	0.52	0.005	0.007	M

THE METEOR SYSTEM OF WINNECKE'S COMET.

CHARLES P. OLIVIER.

This comet, known also as Pons-Winnecke's Comet, belongs to Jupiter's family. During the last half century its orbit has undergone very considerable perturbations, which have greatly altered the elements. Particularly, its perihelion distance has changed from 0.76 astronomical units in 1858 to 0.97 in 1909, and has probably since been increasing. As its inclination is now only 18°, this brought the neighboring arc of the orbit close to that of the Earth, and hence made possible the meteor displays of May-June, 1916.

These meteors were well observed on seven dates between May 21 and June 4 by Mr. John Koep and Mr. Philip Trudelle, both of Chippewa Falls, Wis., and members of the American Meteor Society. It was also seen late in June by several English observers and on July 3 by one American, Mr Raymond Lambert. The maximum occurred on June 28, and it appears to have ceased by about July 4.

This paper deals with the proof of the identity of the meteor orbits with that of the comet, and hence their intimate connection. These meteor orbits, based upon the seven radiants found by the observers mentioned above, were first computed on the usual parabolic assumption and the similarity proving very striking they were next computed as elliptical, assuming for them the same major-axis as the comet's orbit. This made the proof complete, within the limits of error permissible in meteor work, and hence we may conclude that the May-June 1916 meteors move in similar orbits and have a common origin with the Pons-Winnecke Comet.

It is needless to print all the elements here, but the greatest deviations of elements among the seven orbits from those of the comet are given:—

For log e, 0.019; for log q, 0.040; in i, 1°.6; in longitude of perihelion, 20°. The average deviations are less than half as large. Considering the period covered this agreement is quite satisfactory. The complete paper, containing data subsequently received, will appear elsewhere.

BASES OF PHOTOGRAPHIC STELLAR MAGNITUDES.

By J. A. Parkhurst.

There are two fundamental problems in photographic photometry. The first is the problem of fixing the scale of the plate. The second is the problem of basing the magnitude results on some known system. The present paper deals with the second of these problems, that of the different bases for magnitudes, and with the comparison of the merits of two plans for basing the results. In the first plan, magnitudes for a sequence of stars near the North Pole have been carefully determined, and are being used by the method of successive exposures. The alternative method would be to use standard stars on the plate itself, provided that the magnitudes and spectral class of these standards are known. Use is made of the visual magnitudes from Harvard and Potsdam catalogues, allowing for spectral class which is determined on our objective prism plates. The magnitudes from the Potsdam catalogue have been so thoroughly adjusted that the system is homogeneous through the entire sky. The paper gives provisional comparisons of the accuracy to be obtained by the use of these two different methods. In the work now in progress at the Yerkes Observatory, of determining magnitudes in the Kapteyn areas at $\delta = +45°$, the photographic and photo-visual magnitudes, and spectral classes are determined by suitable plates. It is, therefore, possible to base the magnitudes on either photographic or visual catalogue data, by making suitable allowance for the color of the stars.

THE ROTATION AND RADIAL VELOCITY OF THE SPIRAL NEBULA N. G. C. 4594.

By Francis G. Pease.

A direct photograph of the spindle nebula N. G. C. 4594 shows it to be a spiral seen almost edge on. The nebula is crossed by a dark streak which seems to lie at the periphery, being doubtless an outer ring of cooler material or the illuminated edge of the thin disk.

A spectrum exposure of 80 hours was made during March, April, and May, the slit being placed along the major axis of the spindle across the nucleus. The slit was traversed longitudinally at intervals of 1mm by comparison spectra. Measures were obtained by Mr. Adams and Miss Burwell from the resulting spectrum for approximately the entire half of the nebula (2¼ minutes of arc either side of nucleus). The velocity is represented by the curve $v = -2.78x + 1180$; v being velocities in km/sec and x distances in seconds of arc from the nucleus.

From this equation we find:

1. The radial velocity of the nebula is +1180 km, a value in good agreement with that of +1100 found by Slipher.

2. The linear velocity of rotation at a point 2 minutes of arc from the nucleus is over 300 km.

3. Within the limits of accuracy of the measures, the change of rotational velocity is linear although there may be some variation in individual parts of the nucleus.

CIRCUMSTANCES OF THE TOTAL SOLAR ECLIPSE OF JUNE 8, 1918.

By Edison Pettit.

The shadow track goes diagonally across the country passing through Washington, Oregon, Idaho, Wyoming, Colorado, Kansas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, and Florida. The shadow strikes Washington at 2:55 P.M. Pacific time and leaves Florida at 6:42 Eastern time, requiring 47 minutes to cross the country. Important towns visited are Chehalis, Wash.; Baker City, Ore.; Weiser, Idaho; Denver, Col.; Boulder, Col.; Garden City, Kan.; Enid and Guthrie, Okla.; Little Rock, Ark.; Jackson, Miss.; Orlando, Fla. In all some 84 towns are available by rail to the line of totality.

The eclipse occurs in the afternoon at 2:55 in Washington, the duration there being $2^m\ 1^s.9$ and altitude of the Sun 49° 52′; at 4:25 in Colorado, duration $1^m\ 28^s$, altitude 31° 35′; at 5:40 in Florida, duration 58^s, altitude 12° 41′. In general the western stations will be favored with higher Sun and longer duration of the eclipse. Weather conditions also favor the west. Chances are about 3 to 1 in favor of clear weather west of the Mississippi.

The Sun will be on the outskirts of the Milky Way at the time of totality. There will be seven stars brighter than the sixth magnitude within a radius of 4° but none brighter that the fifth. There will be 700 brighter than the ninth in the same field. Aldebaran will be 11° below the Sun, β Tauri 7° above, and Jupiter 5° above.

The long shadow track will make possible the use of the telegraph in comparison of observations during the eclipse. Some attempt should be made to test the value of this method.

There is a need of long focus lenses of 12 inches or greater aperture for use in this eclipse.

PROPER MOTIONS OF STARS IN THE ZONE −10° TO −14°.

By Edward C. Pickering.

Volume 77 of the Harvard Annals gives the positions found in other catalogues of all the stars in the Harvard zone, − 9° 50′ to − 14° 10′.

These positions serve to determine the proper motions of about a thousand stars. They were first platted with positions and times as coördinates. A black line ruled on glass was made to coincide with these points as nearly as possible, and the positions read off for 1800 and 1900. This was repeated on another day. It appeared that the two positions differed in right ascension for 1900 by $\pm 0^s.04$ and in declination by $\pm 0''.3$. The differences in proper motion were $\pm 0^s.0012$ and $\pm 0''.011$. In the first twelve hours there are fourteen stars contained also in the catalogues of Boss and Porter. Of the three catalogues, Boss, Porter, and Harvard, whichever gives a value intermediate between the other two is likely to be the best. Omitting the cases where two catalogues give the same value, we have for the right ascensions, Boss intermediate in 5 cases, Porter in 3, Harvard in 1; for declinations, the cases are 4, 3, 5; for proper motions in right ascension, 4, 2, 6; for proper motions in declination, 2, 3, 7; for all, 15, 11, 19. We may therefore conclude that the Harvard values are at least as good as those in the other catalogues.

SELECTION OF COMPARISON STARS IN FIELDS USED FOR THE DETERMINATION OF STELLAR PARALLAXES.

By J. H. Pitman.

In our preliminary fields, we choose from six to twelve stars of about the same magnitude arranged symmetrically about the parallax star The x-coördinates of these stars are measured on the two best plates in each epoch. The y-coördinates are also measured on one plate in the series which plate is taken as the standard. The remaining plates are then oriented, in the usual way, the same as the standard plate.

The mean position of a star as determined from two plates in any epoch is used as the position of the star at the mean date of the two plates. If then the subscripts $_{1,\ 2,\ 3,\ 4}$ designate the epochs, each star furnishes equations of the form

$$x_1 = P_1 \pi + T_1 \mu + C$$
$$x_2 = P_2 \pi + T_2 \mu + C$$

The points $x_1 - x_1$, $T_1 - T_1$; $x_2 - x_1$, $T_2 - T_1$; etc. are platted as abscissae and ordinates respectively and the points joined by straight lines. Large parallaxes and proper motions can be seen at a glance. The graph furnishes a check, for the lines joining two evening observations and two morning observations should be parallel. The stars showing large positive parallaxes or large proper motions may then be rejected in the final choice of the field.

ON THE CAPTURE OF COMETS BY PLANETS.

By Henry Norris Russell.

It is often stated that the comets of about seventy years' period have been "Captured by Neptune", just as those of about six years' period have been by Jupiter. But, if the present ellipticity of their orbits were due to the effects of a close approach to the planet, their orbits should still pass close to the planet's orbit, (unless the date of capture were so remote that the orbits had been greatly modified by perturbations in the interval).

It is well known that this criterion is satisfied by the comets of period less than ten years. The orbits of 17 out of 36 of these pass within 0.15 astronomical units of Jupiter's orbit, and all the others except Encke's Comet within 0.65 units. But none of the six comets with periods between 60 and 80 years comes nearer to Neptune's orbit than 3.8 astronomical units, while all six come much closer than this to the orbits of Jupiter and Saturn. There is therefore no evidence at all that these comets have been captured by Neptune.

Extending the study to the 31 comets with computed periods between 10 and 1000 years, it is found that the orbits of seven of them pass within 0.5 astronomical units of Jupiter's orbit, of five within the same distance from that of Saturn, and of two within this distance from Uranus. The closest approach to Neptune is 1.22 units and 18 of the comets pass nearer than this to Jupiter.

It might be supposed that the comets which pass near the orbits of the various planets had been captured by them; but, if the comets' orbits were distributed quite at random, the number out of the group of 31 which might be expected, by pure chance, to pass within 0.5 units of the planets' orbits is 6 for Jupiter, 3 for Saturn, 1.5 for Uranus, and 1 for Neptune. There is therefore very little left to be explained otherwise than by chance.

It appears therefore that very few of the comets with periods between 10 and 1000 years can have been captured by encounters with any of the major planets, unless these encounters were so remote that subsequent perturbations have destroyed the evidence of capture.

This is rather surprising, for the researches of H. A. Newton indicate that, for every comet captured by a planet at so close an encounter that its period was reduced to less than that of the planet, there should be many more captured at less close encounters, whose periods after capture were longer.

We might therefore expect to find a considerable number of comets of longer period showing evidence of capture by Jupiter, and their apparent absence demands explanation.

RESULTS OF PHOTOGRAPHIC OBSERVATIONS OF ECLIPSING VARIABLES.

By H. N. Russell, Mary Fowler, and Martha C. Borton.

More than 2000 photographic observations of six eclipsing variables have been derived from estimates made by Miss Leavitt on Harvard plates, and reduced at Princeton, and the resulting light curves have been compared with those derived from the visual observations of Wendell and others. The principal results of the work are as follows:

1. The visual and photographic light curves during eclipse can in all cases be represented by the same geometrical elements (size and shape of the stars, etc.) but the relative brightness of the components, and sometimes the degree of darkening toward the limb, are different in the two cases.

2. For five totally eclipsing systems the average visual range is $2^m.74$, and the average photographic range $3^m.38$. Showing a marked increase of redness at minimum.

These systems consist of small, bright, dense, white components, of spectra B5 to A, eclipsed by large, faint, reddish components of low density, whose spectra must be at least as "late" as G. It seems very clear in this case that the lower temperature belongs to the earlier stage of evolution,

3. The difference in surface brightness (expressed in stellar magnitudes) between the components averages about five times the difference of color-index. When more precise and extensive data are available, this relation should afford a direct method of estimating the surface brightness of the stars in general, and hence their actual diameters.

The average probable error of the photographic magnitude derived from one Harvard plate is $\pm 0^m.117$ for 1019 estimates made in 1903 and $\pm 0^m.068$ for 1031 estimates made in 1914-16. The latter figure represents the accuracy which may reasonably be expected in future.

The Harvard plates evidently contain material for hundreds of very accurate light curves of eclipsing and short-period variables, which should be made available as soon as possible. Future work on this subject will be continued coöperatively by Harvard and Princeton for several years.

5. The times of minimum (mid-eclipse) as determined visually and photographically, differ by amounts averaging about five minutes, and considerably larger than the errors of observation, the photographic minimum being usually but not invariably later than the visual. These differences are still unexplained, but are sufficiently small to show that the visual and photographic rays cannot differ in velocity by more than one or two meters per second, if as much.

ON THE VISIBILITY OF JUPITER BY DAYLIGHT.

By Henry Norris Russell.

It seems not to be generally known that Jupiter is easily visible with the naked eye before sunset in ordinarily clear weather, though there are several references to observations o this sort in astronomical literature, most of them in out-of-the-way places. During the winter of 1915-16, the planet was looked for on clear afternoons just before sunset, with no other aid than rough alignments with trees and buildings, and seen on ten days between December 12 and February 3, being always an easy object when the sky was really clear. It was also seen with the naked eye, after being found with a field glass on February 14, when at an elongation of only 35°. The planet can not be seen like Venus, when the Sun is high, but becomes visible when the Sun's altitude reaches about 5°, These observations were made at Princeton, under ordinary, average, clear weather conditions.

SYSTEMATIC ERRORS IN THE ROWLAND TABLE FOR CLOSE PAIRS OF SOLAR SPECTRUM LINES.

Charles E. St. John and Louise W. Ware.

Work involving the measurement of close pairs of solar lines brought with it the necessity for an investigation concerning the degree of accuracy which could be attained. For simplicity in discussion a limited range of intensities was desirable, and lines of 3 and 4 were chosen as offering the greatest amount of material. In the spectrum region λ 3900 – λ 5270 are thirty pairs made up of such lines, with separations less than 0.35 Å.

The study was based on a comparison of plates taken under different conditions, in five orders, with scales ranging from 1.8 to 0.25 angstrom per millimeter. These were measured by two or more observers, with filar micrometer settings on the maxima and on the edges of lines, and by means of curves registered by the micro-photometer.

The choice of a standard for comparison was made on the basis that the effect of the personal equation for similar exposures would probably be the same, and not detectable in comparisons among the measures; while for plates of different resolution and different appearance, an effective personal equation would show itself in discrepancies. Since agreement among the measures of different orders may be taken as an indication of reliability, the mean against which individual determinations are tested is the mean for those orders whose accordance is equal to the accordance within an order.

The comparison shows a tendency toward over separation in the measures on lines so close together that the background between them differs in intensity from the general background. The effect is greater, the closer the lines: it is greater for the more poorly defined lines of the red end of the spectrum than for the sharper ones of the blue, and for lines poorly defined for any cause; also it is more appreciable with decreased intensity.

The explanation seems to lie in the psychological effects of the difference in contrast for the two sides of the components of a close pair. When one edge is seen against the dense background of the continuous spectrum and the other against the less dense region of overlap between the lines of the pair, the effect is to make the maximum appear closer to the side of greater contrast: the observed separation is too large.

That the same tendency toward over separation is present in the measures of the Rowland table shows when the separations, deduced from the given wave-lengths, are compared with the standard adopted —the mean of agreeing orders. A second comparison involving 54 solar lines with companions and 250 free standing lines indicates that for isolated lines the accidental errors of the Table are less than has been assumed. The errors introduced in the measurement of pairs are somewhat larger and more important because systematic.

ON THE MUTUAL REPULSION OF SOLAR SPECTRUM LINES.

By Charles E. St. John.

It is an accepted deduction from the anomalous dispersion hypothesis that the asymmetry, due to mutual influence between closely adjacent solar lines is such that the centers of the components of close pairs are displaced in opposite directions, that is, the separation is greater in solar than in arc spectra.

The separations of the components in 45 pairs are found to be 0.291 in both solar and terrestrial spectra.

The sun-arc displacements for 213 lines of groups *a*, *b*, and *c*4, 125 lines of groups *c*5 and *d*, and 34 lines of group *e* have been measured. The results for lines with close companions are in the accompanying table.

TABLE I.

SUN-ARC DISPLACEMENTS FOR LINES WITH CLOSE COMPANIONS.

RELATION TO THE MEAN FOR ALL LINES ASSUMING THAT THE ALBRECHT DEVIATIONS REPRESENT ACTUAL DISPLACEMENTS.

Companion	Group	No. of Lines	Sep.	Sun-Arc	Means	Required Relation
To violet	*a, b, c*4	56	0.275	+0.0036	+0.0038	Algebraically larger
" "	*c*5, *d*	21	0.333	−0.0052	−0.0050	than the normal
" "	*e*	6	0.374	+0.0110	+0.0142	by approximately 0.005 Å
To Red	*a, b, c*4	29	0.320	+0.0038	+0.0038	Algebraically smaller
" "	*c*5, *d*	25	0.326	−0.0062	+0.0063	than the normal
" "	*e*	5	0.371	+0.0156	+0.0142	by approximately 0.007 Å

The comparative separations and the sun-arc displacements both show the absence of measurable mutual influence.

A comparison of the Rowland and International wave-lengths made by Albrecht shows an apparent displacement of 0.007 and 0.005 Å to the violet and red for the violet and red components of close solar pairs. The wave-lengths of the 104 solar lines used by him have been measured upon plates of high dispersion. The indicated errors are systematic, the violet and red components being assigned, respectively, too small and too large values in the Rowland table. Large and small Rowland errors correspond to large and small Albrecht deviations. The coefficient of correlation between them is $+0.56 \pm 0.05$. The probable explanation of the correspondence is that the errors and deviations are two phases of the same phenomenon. The deviations then do not furnish valid evidence of mutual influence, on the other hand, the comparative separations in solar and arc spectra, and the sun-arc displacements indicate, within the limits of error, the complete absence of mutual influence.

According to Sir Joseph Larmor, a mutual repulsion between an iron line and a closely adjacent companion is to be looked for only when the adjacent line is due to another substance. A comparison on this basis indicates that the effect is not detectable with the present means of measurement.

Companion	Companion Not Fe		Companion Fe or Weak and ?		
	No. Lines	Sun-Arc	No. Lines	Sun-Arc	
To Violet	30	+0.0040	26	+0.0031	Favorable by 0.001 Å
To Red	19	+0.0041	10	+0.0031	Unfavorable by 0.001 Å

DISTRIBUTION OF COLOR IN CERTAIN SPIRAL NEBULAE.

By Frederick H. Seares.

Photographs of M 51, M 94, M 99, and N. G. C. 3242 were made with the 60-inch reflector on ordinary and on Cramer's "Instantaneous Isochromatic" plates, the latter exposed behind a yellow filter, for the purpose of showing the distribution of the blue and the yellow light in different parts of these nebulae. The exposure times were such that the images of the bluest stars are comparable on the two kinds of plates.

The significant result is that the central nuclei of the spirals are relatively yellow and correspond to the solar type spectrum usually found for such objects, while the knots and condensations scattered along the branches are intensely blue. The planetary nebula, on the other hand, shows no important differences in the distribution of blue and yellow light.

THE COLOR OF THE POLAR SEQUENCE STARS.

By Frederick H. Seares.

The colors of the Polar Sequence stars have been derived by determining the ratio of exposure times necessary to produce blue and yellow images of the same size. An isochromatic plate exposed behind a yellow filter registers the yellow image, while the same plate used without filter gives the blue image. In the simplest case there is one yellow image and a series of three or four blue images for each star, with the exposure times for blue increasing in geometrical progression. The diameters of the blue images platted against the logarithm of the exposure give a curve from which can be read the exposure time for a blue image of the same size as the yellow image. The exposure-ratio compared with similar ratios for stars of known color gives the color-index or the color class.

The method involves neither photographic nor photovisual magnitudes, and is easily made independent of any influence depending upon the brightness of the stars observed. Its application to the polar stars affords, therefore, an excellent indication of the accuracy of the Mount Wilson color-indices, and hence also of the mutual relation of the photographic and photovisual magnitude systems from which the color-indices were derived.

MOUNT WILSON COLOR-INDEX *minus* COLOR-INDEX FROM EXPOSURE RATIO.

Phot. Mag.	O—C	No. stars and values	Phot. Mag.	O—C	No. Stars and values
3.5	0.00	2(12)	10.6	−0.04	6(48)
5.7	+0.03	3(16)	11.4	+0.05	8(92)
6.5	−0.02	4(20)	12.3	+0.03	7(19)
7.5	+0.02	3(20)	13.3	+0.04	12(42)
8.6	−0.03	3(24)	14.1	+0.02	13(31)
9.4	−0.07	3(18)	14.8	0.00	13(26)
			15.5	−0.06	11(21)

The mean results from three series of photographs are shown in the table. They indicate that the errors both in the original color-indices and in those calculated from the exposure-ratios are very small. Their systematic differences can scarcely exceed 0.05 magnitude, and consequently the maximum relative error in the Mount Wilson photographic and photovisual scales, between the 2nd and 16th magnitudes, is also of this order. This confirms and greatly strengthens a conclusion previously announced, namely, that there are no faint stars in the vicinity of the Pole with negative or small positive color-indices. The minimum color-index at the 16th magnitude is of the order of +0.5 magnitude.

THE COLORS OF THE BRIGHTER STARS IN SEVEN GLOBULAR CLUSTERS.

BY HARLOW SHAPLEY.

The determination of the color class and hence, indirectly, of spectral type of the brighter stars in the globular cluster Messier 13 was reported upon a year ago. The investigation has now been extended to six other clusters: Messier 3, 4, 5, 9, 14, and 15. The results previously obtained are completely verified by the new material. The scattering of light in space, even when the great distances separating us from the globular clusters are concerned, is entirely inappreciable, at least in the higher galactic latitudes. This conclusion is based upon the presence of blue stars in all the clusters and upon the absence of abnormally large color-indices. The decrease of average color-index with increasing magnitude is present in Messier 3, 5, and 15 for which numerical results have been obtained, and the preliminary data for the other clusters point to the same result. It is to be noted that this decrease of color with decreasing brightness is here shown to apply only to the three or four brightest magnitudes in clusters that are known to contain stars differing by at least nine magnitudes.

NOTES ON THE SPECTRA OF CEPHEID VARIABLES.

By Harlow Shapley.

About 400 spectrograms of Cepheid variables have been made during the past year with the 10-inch portrait lens and an objective prism of 15° angle. Periodic variations have been found in the spectra of 20 of these stars, including nearly all of the brighter ones. These Cepheids with variable spectra not previously announced are *TT Aquilae*, *S Sagittae*, and *XZ Cygni*. Variations for the latter were found by Mr. Adams with the 60-inch reflector. Conspicuous changes in the spectrum of the irregular variable *R Scuti* are recorded, confirming earlier observations by Espin, Curtiss, and Mrs. Fleming. Data have been collected for the derivation of curves of spectrum variation for several Cepheids.

Using an additional small 30° prism, sufficient dispersion is obtained to show the spectrum lines which vary with the absolute magnitudes of the stars. From a series of 75 spectrograms of stars of known parallax a preliminary curve has been obtained for G-type stars giving the relation between luminosity and intensity of spectrum lines. Based upon this curve, estimates of the absolute magnitudes of four Cepheids serve to show the high luminosity of this type of variable, a result agreeing with that based upon proper motion. The most interesting outcome of the study, however, is the indication that fair estimates of absolute magnitudes of certain types of stars are possible from objective prism spectra, even when the effective aperture, as in the present case, is no greater than four inches.

SPECTROGRAPHIC OBSERVATIONS OF NEBULAE AND STAR CLUSTERS.

By V. M. Slipher.

Spectrograms of spiral nebulae are becoming more laborious now because the additional objects observed are increasingly more faint and require extremely long exposures that are often difficult to arrange and carry through owing to Moon, clouds, and pressing demands on the instrument for other work. The nebulae thus far observed at Flagstaff that belong to the spiral class number twenty-four objects.

The spirals observed since 1914 will not much alter the average velocity of 400 km/sec indicated up to that time for these nebulae or the drift motion remarked upon at that time.

Additional cases of rotating nebulae have been met in the Andromeda Nebula, M 65, M 66, and with less certainty in still other objects. The form of the spectral lines of the Andromeda Nebula suggests a greater angular velocity near the nucleus than farther out. However, measures

for this are difficult and not precise enough to express the motion quantitatively. This type of rotation or internal motion promises to be more common than the planetary disk-like rotation shown by the Virgo nebula N. G. C. 4594.

The spectrum of the Andromeda Nebula is a pure stellar type with no indications of blended absorption lines of different spectral types such as are shown by spectra of the globular star clusters; and the Flagstaff plates show no traces of the bright lines neither of the Wolf-Rayet nor gaseous nebular type. A few spirals such as N. G. C. 4736 seem to possess blended features analogous to those of the globular cluster spectra, in that they appear to have abnormally strong hydrogen absorption lines. The Flagstaff plate of N. G. C. 4449 has gaseous nebular bright lines on a continuous spectrum, whereas Wolf reported a solar type spectrum for it. N. G. C. 5236, a fine type of spiral, has bright hydrogen lines and faint ones of nebulium superposed upon an early type star spectrum.

The spectra of the star clusters show the blending of light of stars of different spectral types, with the proportion of light of early and late type stars varying from cluster to cluster. Thus M 15 is bluish, M 3 and M 5 are relatively yellowish. The velocity of the clusters seems to be much lower than that of the spiral nebulae. M 13 and M 3 are among those showing the most speed. Unlike the spirals the clusters seem to incline toward negative velocity.

SPECTRAL EVIDENCE OF A PERSISTENT AURORA.

By V. M. Slipher.

During the last fifteen months spectrograms have been made at Flagstaff of the night sky with a single-prism spectrograph of high light-power for the purpose of testing for general auroral illumination of the sky. Isochromatic plates were employed in order to record the characteristic auroral line near λ 5570. More than fifty plates were exposed and all plates show this strong green auroral line, thereby disclosing the existence of a general aurora, permanent at least for the period of these observations.

THE VAN VLECK OBSERVATORY.

By Frederick Slocum.

This paper describes the Van Vleck Observatory of Wesleyan University at Middletown, Conn., which was dedicated June 16, 1916.

The Observatory is the gift of the late Joseph Van Vleck of Mont-

clair, N. J., brother of the late John M. Van Vleck. It is located on the top of a hill about 300 yards due west of the chapel. The building material is Portand brownstone. The cost of the building and its equipment was about $70,000.

The main part of the building is 40x80 feet, one story high, and contains a class-room, library, time-room, computing-room, director's office, and an assistant's room. In a wing extending to the west is a transit-room containing two three-inch transits. At the end of a second wing extending to the east is the tower for the chief instrument; a telescope of 18½ inches aperture and 26 feet focal-length. The completion of the lens has been delayed by the war and the 12-inch lens from the old observatory is being used temporarily in the new mounting. In addition to the telescope and transits mentioned above, the Observatory has a good equipment of apparatus for instruction and research.

For convenience in observing, the floor of the tower is an elevator, 33 feet in diameter with a vertical range of 10 feet.

The paper was fully illustrated by lantern slides.

(*To be Continued*).

THE PARALLAXES OF PROCYON AND ALTAIR.

S. A. MITCHELL.

Elsewhere in this issue of Popular Astronomy at page 23 appear the results of the determinations of stellar parallax obtained at the Leander McCormick Observatory of the University of Virginia. It may be of interest to give here the details of the measures of the two brightest stars so far finished, Procyon and Altair.

The parallax results have been obtained by photography with the 26-inch refractor in the manner described by Schlesinger and by Slocum and Mitchell in the Astrophysical Journal. In brief, the photographs were taken by means of color filter and Cramer isochromatic plates. Measurements were made to determine the parallactic shift in right ascension of the parallax star with reference to certain comparison stars, the measurements being made on the original photograph, and being carried out to the ten-thousandth part of a millimeter. The comparison stars were chosen so that their center of position should be as near as possible to the parallax star. The method followed in the reductions was the admirable one invented by Schlesinger, and known as the method of "dependences". By this method it is unneces-

sary to find the constants of the plate, as is usually the case in photographic reductions. The dependences give essentially a system of weights for the different comparison stars depending on their positions with respect to the parallax star.

Ordinarily two exposures were made on each plate, the plate being shifted about 2.5mm between exposures. The quality of the plate was judged during the measurement, the system of weights, adopted being that given in *Astrophysical Journal*, **38**, 3, 1913. At times, only one exposure was made, or measured, on a plate. When this happened is shown in the table.

The following plates were taken on Procyon:

TABLE I.

PLATES OF PROCYON.

No.	Date	Hour Angle	Observer	Weight of plate	
		h			
1050	1915 Mar. 13	+0.2	A	0.7	
1059	Mar. 14	+0.2	M	0.7	
1069	Mar. 17	+0.2	A	1.0	
1123	Mar. 28	+0.8	M	1.0	
1932	Oct. 30	+0.4	M	1.0	
1933	Oct. 30	+0.7	M	1.0	
1981	Nov. 7	−0.6	A	0.8	
1982	Nov. 7	−0.3	A	0.9	
1995	Nov. 9	−1.0	A	0.9	
1996	Nov. 9	−0.8	A	0.9	
2083	Nov. 27	+0.1	M	0.7	
2084	Nov. 27	+0.4	M	0.7	One image
2460	1916 Mar. 11	+0.6	A	1.0	
2461	Mar. 11	+1.0	A	0.7	
2523	Mar. 25	+0.2	A	1.0	
2524	Mar. 25	+0.7	A	0.8	

M = S. A. Mitchell; A = H. L. Alden; G = P. H. Graham.

COMPARISON STARS.

No.	Diameter	X (Right Ascension)	Y (Declination)	Dependence
	mm	mm	mm	
1	0.12	−53.6	+19.1	0.203
2	.19	−40.0	−31.6	.214
3	.14	+16.7	+54.4	.183
4	.21	+16.8	+ 2 8	.197
5	.23	+60.1	−44.7	0.203
Procyon	0.28	− 0.9	− 1.5	

REDUCTIONS FOR PROCYON.

Plate	Solution (m) mm	Weight (p)	Parallax Factor (P)	Time in Days (t)	Residual (v) mm	$\sqrt{p}.v$ in Arc
1050	− 0.0263	0.7	− 0.853	−230	+ 0.0019	+ 0".03
1059	− .0222	0.7	− .862	−229	− .0024	− .04
1069	− .0249	1.0	− .886	−226	− .0003	− .01
1123	− .0278	1.0	− .953	−215	+ .0006	+ .91
1932	− .0213	1.0	+ .947	+ 1	+ .0027	+ .05
1933	− .0200	1.0	+ .947	+ 1	+ .0014	+ .03
1981	− .0182	0.8	+ .901	+ 9	− .0018	− .03
1982	− .0202	0.9	+ .901	+ 9	+ .0002	.00
1995	− .0208	0.9	+ .887	+ 11	+ .0004	+ .01
1996	− .0206	0.9	+ .887	+ 11	+ .0002	.00
2083	− .0225	0.7	+ .712	+ 29	− .0021	− .04
2084	− .0213	0.7	+ .712	+ 29	− .0033	− .06
2460	− .0574	1.0	− .843	+134	+ .0002	.00
2461	− .0551	0.7	− .843	+134	− .0021	− .04
2523	− .0599	1.0	− .942	+148	− .0001	.00
2524	− 0.0624	0.8	− 0.942	+148	+ 0.0025	+ 0.04

The normal equations are:

$$\begin{aligned} 13.8\ c - 1.904\ \mu - 0.1491\ \pi &= -0.4344 \\ +24.2527\ \mu + 2.9987\ \pi &= -0.1135 \\ +10.8276\ \pi &= +0.1385 \end{aligned}$$

from which there results:

$$\begin{aligned} c &= -0.03257\text{mm} \\ \mu &= -0.00907 = -0''.189 \text{ per 100 days} \\ \pi &= +0.01486 = +0''.309 \pm 0''.007 \end{aligned}$$

Probable error corresponding to unit weight $= 0.00116\text{mm} = \pm\ 0''.024$.

The proper motion in right ascension per year along a great circle is

$$\mu_\alpha \cos\delta = -0''.690$$

The value found by Boss in the Preliminary General Catalogue is $-0''.666$

The above reductions were all carried out in terms of millimeters. Final values were found in seconds of arc by multiplying by the scale value of the photographs, 1 mm = 20".8.

The accuracy with which parallax determinations may be obtained from photographs depends on the following: 1), Scale value, the telescopes of greatest focal length should give the smallest probable errors, 2), Definition, and 3), Freedom from guiding error. It has been found from experience that the smallest errors of measurement are made when the stellar images are small, sharply-defined, well-blackened discs with clean-cut edges. Poor seeing makes the images larger in diameter,

and causes fuzzy edges. One of the most fruitful sources of error is the so-called "guiding error". What is meant by this is as follows: If we assume the case that an exposure is being made of ten minutes duration, that the guiding is perfect with the exception of ten to twenty seconds of the total time, when the star is allowed to drift, which is usually caused by the driving clock not performing exactly. On the fainter stars there may be no perceptible effect of this slight period of drifting of the telescope, but on the brighter stars a slight trail may be seen which becomes the more prominent, the brighter the star. Best results are, therefore, obtained when the guiding is as perfect as possible, and when all the stars to be measured have the same diameters on the photographic plate The closer one approximates to these two conditions, the nearer will results be freed from guiding error. Ordinarily, the parallax star is many times brighter than the comparison stars. It is, therefore, necessary to choose comparison stars of nearly equal brightness, and cut down the exposure on the parallax star so that it may be of nearly the same diameter as the comparison stars.

Following the plan adopted by Schlesinger with the 40-inch Yerkes refractor, most parallax observers have adopted the use of a sector placed close to the center of the photographic plate and rotated by means of a small electric motor. In this manner it is readily possible to decrease the relative exposure on the parallax star one hundred times, or in other words, to diminish its light by five magnitudes. If the opening of the sector is diminished to less than one one-hundredth of the total circumference, there is a possibility that new difficulties may arise from diffraction of the light as it passes through the small slit.

The average magnitude of the comparison stars used at the McCormick Observatory with Procyon and Altair was 9.5. How is it possible to cut down the brightness of these stars eight or nine magnitudes? The entire series of plates on Procyon were taken with a single sector in which the opening was diminished as small as possible without introducing diffraction effects. Following a suggestion, kindly communicated to me by Professor Frost, a sector was made with two leaves on the same hub, and rotating at different speeds. The six last plates on Altair were taken with the double sector. The measures made for diameters of images for Altair were from one of these plates, π3250. The measures show that the comparison stars were all of nearly the same diameter, with the image of Altair very slightly larger.

The following values of the parallax of Procyon have been obtained;

Parallax	Authority	Method
+0".299 ±0".038	Wagner	Meridian Circle
0.34 ± .039	Flint	Meridian Circle
0.334 ± .015	Elkin	Heliometer
0.287 ± .012	Miller	Photography
+0.309 ± .007	Mitchell	Photography

The mean value of the Parallax of Procyon from all authorities weighted according to their probable errors is:

$$0''.309$$

The above values of the parallaxes are unusually consistent. When one takes into consideration the very great brightness of Procyon, and the consequent difficulty in the elimination of the constant errors, these values are extraordinarily consistent.

A contrast of the method of determining the parallaxes by photography and by the older method of the heliometer is not without interest. The parallax of Procyon was determined by Elkin using the six-inch Yale heliometer. Thirteen comparison stars were used altogether. The observations were divided into seven series, in six of which the measures were made with respect to two comparison stars, while in the seventh only one comparison star was used. The following values were obtained:

$\pi = +$ 0.257	Series I
.461	II
.367	III
.366	IV
.503	V
.294	VI
+0.228	VII

Weighted mean, $\pi = 0''.334 \pm 0''.015$.

Altogether 128 observations were made, beginning in 1885, October 15 and ending 1893, December 7. The observations, however, were not continued throughout the whole period.

The writer here wishes to express his admiration for and appreciation of the magnificently accurate results obtained with the Yale heliometer, and to voice his amazement that such consistently accurate results have been obtained with an instrument of such short focal length.

The work required to obtain a parallax by the heliometer is enormously greater than is demanded by photography.

Altair.

The plates on Procyon were taken at three successive seasons, the photographs of Altair at four successive seasons, as given in the following table:

PLATES OF ALTAIR.

No.	Date	Hour Angle	Observer	Weight of plate
1417	1915 June 30	0.0	G	0.8
1418	June 30	+0.4	G	0.7
1426	July 2	+0.3	A	0.7
1427	July 2	+0.8	A	0.9
1653	Sept. 11	−0.2	A	0.6
1654	Sept. 11	+0.1	A	0.9
1665	Sept. 12	−0.3	M	0.6
1720	Sept. 19	−0.2	M	1.0
1732	Sept. 22	−0.2	A	1.0
1760	Sept. 25	−0.7	M	1.0
1761	Sept. 25	−0.2	M	1.0
2679	1916 May 27	−0.7	M	0.5
2680	May 27	−0.4	M	0.7
2694	June 1	−0.7	M	0.8
2695	June 1	−0.4	M	0.7
2753	June 22	−0.6	M	0.8
3046	Sept. 20	−0.2	M	0.8
3114	Sept. 30	−0.2	A	0.8
3119	Oct. 1	−0.2	M	0.7 one image
3120	Oct. 1	+0.2	M	0.7 one image
3178	Oct. 12	+0.2	M	1.0
3250	Oct. 23	+0.1	M	1.0
3251	Oct. 23	+0.4	M	0.8

COMPARISON STARS.

No.	Diameter	X(Right Ascension)	Y (Declination)	Dependence
	mm	mm	mm	
1	0.12	−44.7	+21.8	0.182
2	.14	−28.2	−48.4	.221
3	.12	+11.8	− 4.5	.204
4	.14	+16.8	+50.7	.176
5	.12	+44.3	−19.6	0.217
Altair	0.19	+ 0.6	− 3.0	

REDUCTIONS FOR ALTAIR.

Plate	Solution (m)	Weight (p)	Parallax Factor (P)	Time in days (t)	Residual (v)	$l/\bar{p}.v$ in Arc.
	mm				mm	
1417	+0.0240	0.8	+0.283	−240	−0.0029	−0".05
1418	.0186	0.7	+ .283	−240	+ .0025	+ .04
1426	.0186	0.7	+ .251	−238	+ .0023	+ .04
1427	.0214	0.9	+ .251	−238	− .0005	− .01
1653	.0185	0.6	− .795	−167	− .0035	− .05
1654	.0148	0.9	− .795	−167	+ .0002	.00
1665	.0146	0.6	− .805	−166	+ .0004	+ .01
1720	.0170	1.0	− .866	−159	− .0021	− .04
1732	+0.0150	1.0	−0.888	−156	−0.0001	0.00

Plate	Solution (m) mm	Weight (p)	Parallax Factor (P)	Time in days (t)	Residual (v) mm	$\sqrt{p}$. v. in Arc.
1760	+0.0130	1.0	−0.908	−153	+0.0019	+0.04
1761	.0134	1.0	− .908	−153	+ .0015	+ .03
2679	.0494	0.5	+ .743	+ 92	+ .0004	+ .01
2680	.0500	0.7	+ .743	+ 92	− .0002	.00
2694	.0496	0.8	+ .686	+ 97	.0000	.00
2695	.0500	0.7	+ .686	+ 97	− .0004	− .01
2753	.0481	0 8	+ .397	+118	.0000	.00
3046	.0420	0.8	− .879	+208	− .0009	− .02
3114	.0425	0,8	− .940	+218	− .0013	− .02
3119	.0412	0.7	− .945	+219	.0000	.00
3120	.0393	0.7	− .945	+219	+ .0019	+ .03
3178	.0398	1.0	− .977	+230	+ .0019	+ .04
3250	.0422	1.0	− .974	+241	+ .0003	+ .01
3251	+0.0444	0.8	−0.974	+241	−0.0019	−0.03

The normal equations are:

$$18.5\,c - 0.504\,\mu - 7.6896\,\pi = +0.5704$$
$$+66.4464\,\mu - 3.9192\,\pi = +0.4187$$
$$+11.4770\,\pi = -0.1797$$

From these there results:

$$c = +0.03540 \text{ mm}$$
$$\mu = +0.00719 \text{ per } 100 \text{ days}$$
$$\pi = +0.01051 = +0''.218 \pm 0''.007$$

Probable error corresponding to unit weight $= \pm 0.00100$mm $= \pm 0''.021$.

Proper motion per year in right ascension along a great circle is,

$\mu_\alpha \cos\delta = +0''.536$ per year Observed
$= +0\ .544$ " " Boss Preliminary General Catalogue

The following determinations have been made of the parallax of Altair:

Parallax		Authority	Method
+0''.232	±0''.019	Elkin	Heliometer
+0.22	±0.047	Flint 1	Meridian circle
+0.079	±0.033	Flint 2	Meridian circle
+0.216	±0.073	Jewdokimov	Meridian circle
+0.218	±0.007	Mitchell	Photography

Omitting Flint 2, the mean of all authorities weighted according to their probable errors is:

0''.220

A comparison of the results obtained by photography at the McCormick Observatory with other authorities follows:

Star	Parallax		Proper Motion in R.A.	
	Mitchell	All Authorities	Mitchell	Boss
Procyon	+0".309	+0".309	—0".69	—0".67
Altair	+0.218	+0.220	+0.54	+0.54

That the results of Procyon and Altair seem to be fairly free from systematic errors is shown by the following considerations: 1), Small size of the probable errors, 2), The close agreement of the McCormick values for parallax with the mean of all authorities, and 3), The near agreement of the values for proper motion in right ascension as compared with the Preliminary General Catalogue of Boss, in spite of the fact that the photographs in time stretch over only one one-hundredth of the interval of Boss. Not one of these reasons separately, nor even the three combined make certain that the parallaxes are free from systematic errors. This can be tested only by the appearance of other and better parallax results.

Leander McCormick Observatory,
University of Virginia.
December 9, 1916.

ASTRONOMICAL PHENOMENA IN 1917.

ECLIPSES.

In the year 1917 there will be seven eclipses, four of the sun and three of the moon. This is the greatest number of eclipses that can occur in any year. There may also be seven eclipses in a year distributed as follows: five of the sun and two of the moon. The unusual circumstance of three lunar eclipses in a year occurred also, according to Young's Astronomy, in 1787. In that year they occurred on January 3, June 30 and December 24. In 1917 they will occur on January 7, July 4 and December 27, the dates in the latter case being the astronomical dates at Greenwich. It is easily seen that in both these years the reason for the three lunar eclipses is that the first one occurs very near the beginning of the year, and therefore the sun moves around and reaches the same node a second time before the close of the year.

The list of eclipses for the year with the Greenwich time for each follows.

				h	m
I	A total eclipse of the moon	January	7	19	44.6
II	A partial eclipse of the sun	January	22	19	28.3
III	A partial eclipse of the sun	June	19	1	16.2
IV	A total eclipse of the moon	July	4	9	38.6
V	A partial eclipse of the sun	July	18	14	42,5
VI	An annular eclipse of the sun	December	13	21	23.4
VII	A total eclipse of the moon	December	27	21	46.3

Only two of these, I and VII, will be generally visible throughout the United States. The partial eclipse of the sun on July 18 will also be partly visible in the northwestern section. The annular eclipse of December 13 would be seen best by an observer in the region of the south pole. Further reference to the eclipse of January 7 will be found on page 17 of this issue.

THE PLANETS.

The drawings, Figures 1 and 2, are designed to facilitate the location and the identification of the various planets throughout the year. The brightest of the planets can easily be distinguished from the stars by anyone who is at all familiar with the sky. Some of the fainter planets and those not visible to the naked eye will be located only by some knowledge of their position in the sky with reference to the known stars in that region. These charts also enable one to determine whether a particular planet is visible at a given time. Each planet at least once during the year will be invisible for a period of a month or two because of its nearness, in angular position, to the sun. Each planet also will sometimes be visible only on the early morning, and at other times only in the early evening. The former situation exists when the planet is only a short distance west of the sun, and the latter when the planet is a short distance to the east of the sun. The position of the sun is not indicated, but its path is indicated by the heavy line which intersects the margin of each drawing at 0°. This line is the ecliptic, and the positions of the sun on the ecliptic may be found by noting that it will be approximately at 0^h on March 22, at 2^h on April 22, at 4^h on May 22, and so on throughout the year. The positions and relative brightness of the stars also are indicated so that the naked eye planets can be found by comparing the appearance of the sky with the chart and noting the new object for which no star position is assigned.

Mercury, as will be seen from Figure 1, will end the year only a short distance from its place at the beginning of the year, having made almost an entire circuit of the sky. Because of its small orbit about the sun it will always be in that part of the sky in which the sun is, and only occasionally will be far enough out from the sun to be visible. Its actual motion around the sun is continuous, but as seen from the earth, because of the earth's motion and that of Mercury, it appears sometimes to have reversed its motion in the sky. This occurs, as seen from the chart, in January, May and September: Mercury will be visible in the western sky just after sunset on and near the following dates: Janury 2, April 24, August 22, and December 16. It will be visible in the eastern sky just before sunrise on and near the following dates: February 11, June 11, and October 4. At the appearance on April 24 it will be very near the Pleiades.

Venus, the planet next to Mercury as one passes out from the sun, follows the path indicated by the heavy dotted line in Figure 1. It has an uninterrupted motion eastward throughout the year, completing about one and one-fifth times the complete circuit of the sky. Venus, being farther from the sun than Mercury, will be visible for longer periods than Mercury. At the beginning of the year it will be visible near the eastern horizon at sunrise. It will be moving eastward a little more rapidly than the sun. By February 1 it will have moved so close to the sun as to be practically invisible. During March, April and May it will move eastward along with the sun and be invisible during this period. During the latter part of June it will become visible again in the western sky, being higher and higher on each succeeding day at sunset. It will be a beautiful, brilliant, conspicuous evening star during the autumn months. It will reach its greatest brightness as seen from the

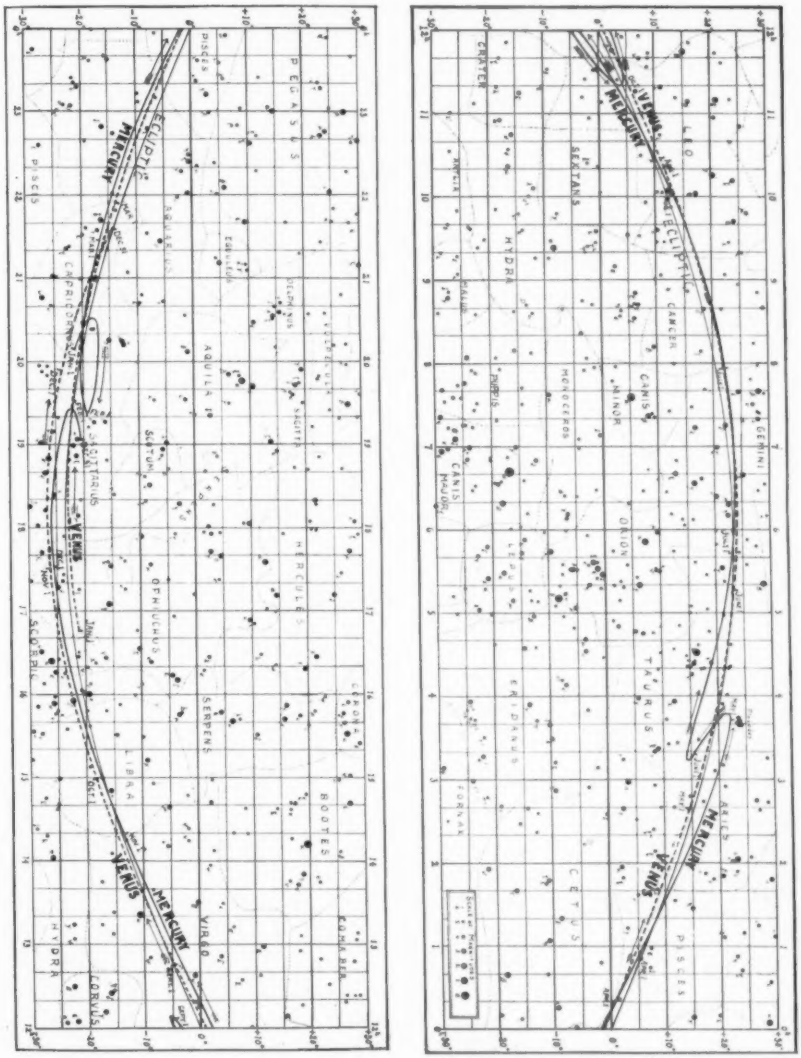


FIG. 1. Apparent paths of the planets Mercury and Venus among the stars during the year 1917.

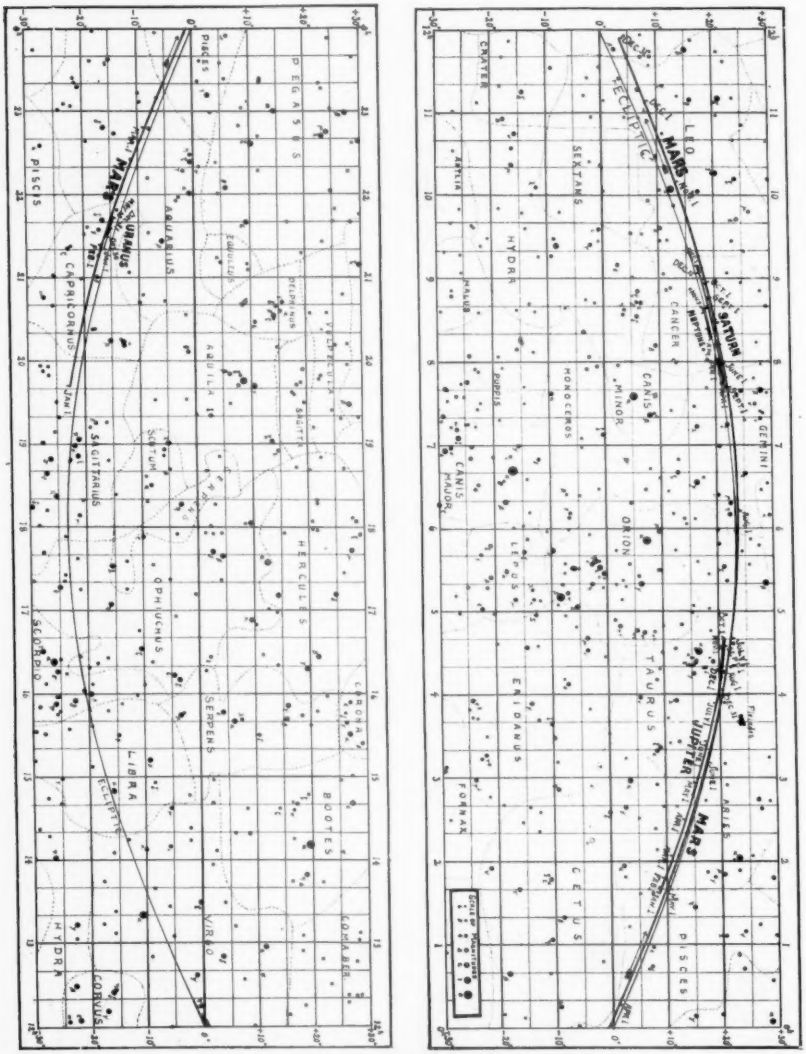


FIG. 2. Apparent paths of the planets Mars, Jupiter, Saturn, Uranus and Neptune among the stars during the year 1917.

earth in December. It will then be about one hundred times as bright as Aldebaran, the ruddy first magnitude star in Taurus, and about two hundred and fifty times as bright as the Pole star.

Mars will begin the year a little to the east of the sun, but too near the sun to be visible. The sun will overtake Mars in its easterly motion, and pass it about March 1. Because the sun and Mars are moving at almost the same rate towards the east Mars will be invisible during the first half of the year. About July 1 it will rise long enough before the sun to become visible in the morning sky for a little while. It will, however, not be high enough in the sky for favorable observation before the latter part of the year. On December 11 Mars will be in quadrature with the sun and will therefore be near the meridian at sunrise. Mars will not be at opposition during this year.

Jupiter will move from the constellation Pisces eastward into the constellation Taurus, and end the year with a retrograde motion in Taurus, a short distance in

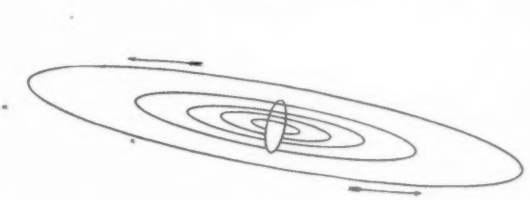


FIG. 3. SATELLITES OF JUPITER, 1917.
Apparent orbits of five of the satellites of Jupiter at date of opposition, November 28, 1917, as seen in an inverting telescope and elongated in the ratio of three to one in the direction of their minor axes.

the sky to the southeast of the Pleiades. Jupiter will be well up in the sky at sunset at the beginning of the year. It will be in a fairly favorable position for observation during January and February, and can be observed during March. In April it will be too near to the sun and early in May the sun will pass it. In July it will

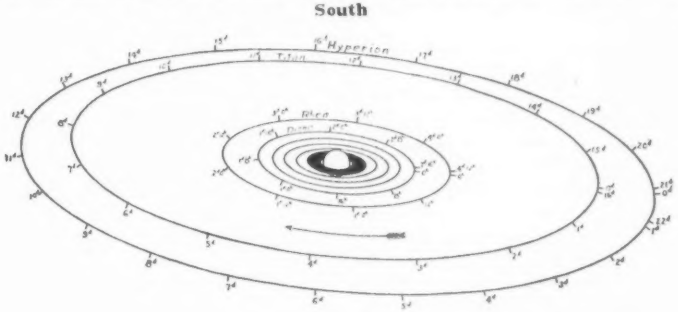


FIG. 4. SATELLITES OF SATURN, 1917.
Apparent orbits of the seven inner satellites of Saturn at date of opposition, January 17, 1917, as seen in an inverting telescope.

again appear as a morning star, rising earlier and earlier each day. Late in November it will be in opposition to the sun and will then rise at sunset. For a month or so previous to this it will be in the eastern sky late at night. Figure 3 shows the orbits of the satellites of Jupiter at the time of its opposition, November 28, 1917.

Saturn will begin the year with a slight retrograde motion in Gemini and will then move eastward into Cancer. It will be opposite to the sun on January 17, and will therefore be in very good position for observation. On April 14 it will be on the meridian at sunset. It will continue to be visible in the west in the evening until the latter part of June. In September it will appear again as a morning star, the sun having passed it in the latter part of July. In November it will rise at midnight and at the end of the year it will rise shortly after sunset.

Figure 4 shows the orbits of the satellites of Saturn at the time of the opposition January 17, 1917.

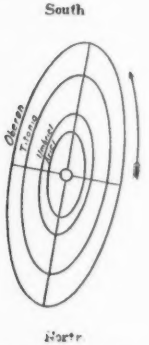


FIG. 5. SATELLITES OF URANUS, 1917. Apparent orbits of the satellites of Uranus at date of opposition, August 14, 1917, as seen in an inverting telescope.

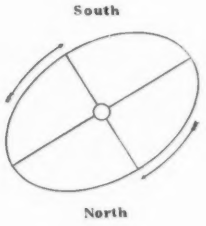


FIG. 6. SATELLITE OF NEPTUNE, 1917. Apparent orbit of the satellite of Neptune at date of opposition, January 23, 1917, as seen in an inverting telescope.

Uranus will describe a short path in the eastern part of the constellation Capricornus. At the beginning of the year it will be visible in the western sky. During February, March and a part of April it will be too near to the sun to be seen. After this it will appear again in the morning sky. Uranus will be opposite the sun about the middle of August. Figure 5 shows the orbits of the satellites of Uranus at the date of opposition.

Neptune shifts its position a little, first toward the west and then toward the east, then again toward the west, in the constellation Cancer. Its position at the end of the year is only about three degrees east of its position at the beginning of the year. It will be in the same part of the sky as Saturn throughout the year. It will be too near the sun to be seen during the latter part of July and during August and in the early part of September. Neptune is quite faint and can be distinguished from a star only by experience. It is also possible to identify this planet by its slight change in position relative to the neighboring stars from day to day. Figure 6 shows the orbit of the satellite at the time of the opposition of the planet on January 23.

The Figures 3, 4, 5, 6 of this article are copied from the *American Ephemeris* for 1917.

From month to month as in previous years we shall print information concerning the phenomena relating to the satellites of Jupiter and of Saturn whenever these planets are favorably situated. This information also is obtained from the *American Ephemeris.*

COMETS.

The comet discovered by Wolf on April 27, 1916, designated as "comet *b* 1916" may develop into a conspicuous and interesting object during this year. When discovered it was at a great distance from the sun. It is due to reach perihelion in June 1917, and, as most comets become brighter and brighter as they approach the sun, this one, being bright enough to be discovered at such a great distance may become bright enough to be seen with the naked eye.

Of the periodic comets two which have been seen on two previous occasions are due at perihelion early in 1918 and will therefore be coming in during this year. These are the comets known as Brooks' (1889 V) and Faye's. The former will approach perihelion from behind the sun, which will be unfavorable to its discovery before that time. After perihelion too it will be near the sun for four or five months as seen from the earth and hence may not be seen at this return. The latter also will approach perihelion on the side of the sun opposite the earth. At perihelion, however, is will be well out in the sky from the sun and may possibly be found by searching for it about the time of perihelion. Three or four months before perihelion this comet will be in opposition to the sun and will therefore present favorable conditions for searching. Unfortunately, however, the comet will probably be very faint at this early date.

Three other comets which have been seen only once will return to perihelion during this year: Barnard 1884 II, in the early part of January; Swift 1895 II, about the middle of April; Spitaler 1890 VII, in August. For the first, the earth will be almost directly opposite the sun at the time it is at perihelion. The second will be in a position to be accessible about the time of perihelion and for a few months following. The third, like the second, will be out in the sky from the sun at the time of perihelion and thereafter. Should ephemerides of these be available it would be worth while to search for these comets, which are known to be in the neighborhood of the sun during this year.

METEORS.

One of the first questions the astronomer is asked by a person who is not acquainted with the elementary facts of astronomy is the explanation of the "falling stars". A sudden flash of light in the sky always attracts attention and excites wonder. The phenomenon of a "falling star" is the incandescence of a body, usually very small, which in its motion through space happens to come within the scope of the earth's attraction and is drawn into the earth's atmosphere with a velocity so great as to cause the body to glow from the heat caused by the friction with the atmosphere. It is estimated that several million such bodies strike the earth daily, most of which we are entirely unconscious of. The few that are seen by the casual observer seem to be entirely at random. However, there are definite dates when, in certain localities in the sky, they may be expected to occur more frequently than at other times. Below is given a list of such dates and positions, taken originally from the list given by Mr. W. F. Denning in the *Campanion to the Observatory.*

Date		Radiant α	Radiant δ	Character
		°	°	
Jan.	2-3	230	+53	Swift; long paths.
Apr.	20-22	271	+33	Swift.
May	1-6	338	− 2	Swift; streaks
July	28-30	339	−11	Slow; long.
Aug.	10-13	46	+57	Swift; streaks.
Oct.	18-20	92	+15	Swift; streaks.
Nov.	14-16	150	+22	Swift; streaks.
Nov.	17-23	25	+43	Very slow; trains.
Dec.	10-12	108	+33	Swift: short.

VARIABLE STARS.

The times of maxima of about eighty short period variables, and the times of minima of more than one hundred others have again been computed at the Goodsell Observatory for the year 1917, and will be published a month in advance throughout the year. Every effort is made to keep these predictions corrected in accordance with the best elements of the various stars. Many of these stars are visible through their entire range with a small telescope, and since the change in brightness is frequently quite rapid near maximum or minimum, it is an interesting bit of work for the user of a small instrument to observe the actual variation.

In addition to the predicted times of the maxima and minima, there will appear each month actual estimates of the brightness of certain long period variables as furnished by the members of the American Association of Variable Star Observers. This is not a new feature as this work has now been in progress for several years.

OCCULTATIONS.

As in former years we shall print each month the list of stars to be occulted by the moon during the succeeding month. This list is taken from the *American Ephemeris*. It may be useful to those of our readers who do not have access to the *American Ephemeris*. Any one who has never witnessed an occultation will be surprised to note the rapidity with which the phenomenon occurs. This can be observed with a small telescope and even with opera glasses.

Occultations Visible at Washington.

[*From the American Ephemeris*].

Date 1917		Star's Name	Magnitude	IMMERSION. Washington M.T. h	m	Angle from N. °	EMERSION. Washington M.T. h	m	Angle from N. °	Duration h	m
Feb.	2	5 Geminorum	5.9	13	24	158	14	6	234	0	42
	3	87 B. Gemin.	5.8	5	13	60	6	15	305	1	2
	3	44 Geminorum	5.9	14	4	104	15	9	298	1	5
	4	85 Geminorum	5.2	14	28	52	14	58	1	0	29
	6	ξ Leonis	5.1	16	23	57	16	52	4	0	29
	14	3 Scorpii	5.9	16	3	136	17	14	260	1	11
	25	47 B. Arietis	6.5	8	37	46	9	30	286	0	53
	26	ε Arietis	4.6	6	26	106	7	36	228	1	10
	27	36 Tauri	5.6	11	28	88	12	24	273	0	56
	28	*k* Tauri	5.6	10	52	118	11	52	256	1	0

Saturn's Satellites for February, 1917.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$.

Feb. 1 20.3 E	Feb. 8 10.6 E	Feb. 15 12.2 W	Feb. 22 13.8 E
2 18.9 E	9 8.2 E	16 10.8 W	23 12.4 E
3 17.5 E	10 7.8 E	17 9.4 W	24 11.0 E
4 15.1 E	11 17.7 W	18 8.0 W	25 9.6 E
5 14.7 E	12 16.3 W	19 17.9 E	26 8.2 E
6 13.3 E	13 14.9 W	20 16.5 E	27 18.2 W
7 12.0 E	14 13.5 W	21 15.2 E	28 16.8 W

II. Enceladus. Period $1^d\ 8^h.9$.

Feb. 1 10.6 E	Feb. 8 6.9 E	Feb. 15 3.2 E	Feb. 21 23.6 E
2 19.5 E	9 15.8 E	16 12.1 E	23 8.5 E
4 4.4 E	11 0.6 E	17 20.9 E	24 17.3 E
5 13.2 E	12 9.5 E	19 5.8 E	26 2.2 E
6 22.1 E	13 18.4 E	20 14.7 E	27 11.1 E
			28 20.0 E

III. Tethys. Period $1^d\ 21^h.3$.

Feb. 2 5.2 E	Feb. 9 18.3 E	Feb. 17 7.5 E	Feb. 24 20.7 E
4 2.5 E	11 15.7 E	19 4.8 E	26 18.0 E
5 23.8 E	13 12.9 E	21 2.1 E	28 15.3 E
7 21.1 E	15 10.2 E	22 23.4 E	

IV. Dione. Period $2^d\ 17^h.7$.

Feb. 3 1.1 E	Feb. 11 6.1 E	Feb. 19 11.0 E	Feb. 24 22.4 E
5 18.8 E	13 23.7 E	22 4.7 E	27 16.0 E
8 12.5 E	16 17.4 E		

V. Rhea. $4^d\ 12^h.5$.

Feb. 2 13.2 E	Feb. 13 13.8 E	Feb. 22 14.5 E	Feb. 27 2.9 E
9 1.5 E	18 2.2 E		

VI. Titan. Perion $15^d\ 23^h.3$.

Feb. 7 23.5 E	Feb. 15 15.4 W	Feb. 23 21.1 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Feb. 7 2.1 W	Feb. 16 14.8 E	Feb. 28 4.4 W

VIII. Iapetus. Period $79^d\ 22^h.1$.

Jan. 30 1.7 I	Feb. 17 15.9 W	Mar. 8 23.6 S

IX. Phoebe. Period $523^d\ 15^h.6$.

	α Ph. $-$ α Sat.	δ Ph. $-$ δ Sat.		α Ph. $-$ α Sat.	δ Ph. $-$ δ Sat.
	m s	′ ″		m s	′ ″
Feb. 1	+2 28.0	−5 16	Feb. 15	+2 28.2	−4 33
3	28.3	5 10	17	27.9	4 27
5	28.5	5 04	19	27.5	4 21
7	28.7	4 58	21	27.0	4 14
9	28.7	4 52	23	26.4	4 08
11	28.6	4 46	25	25.7	4 01
13	+2 28.5	−4 40	27	+2 25.0	−3 55

The hours are numbered continuously through 24 hours, beginning with 0^h at noon.

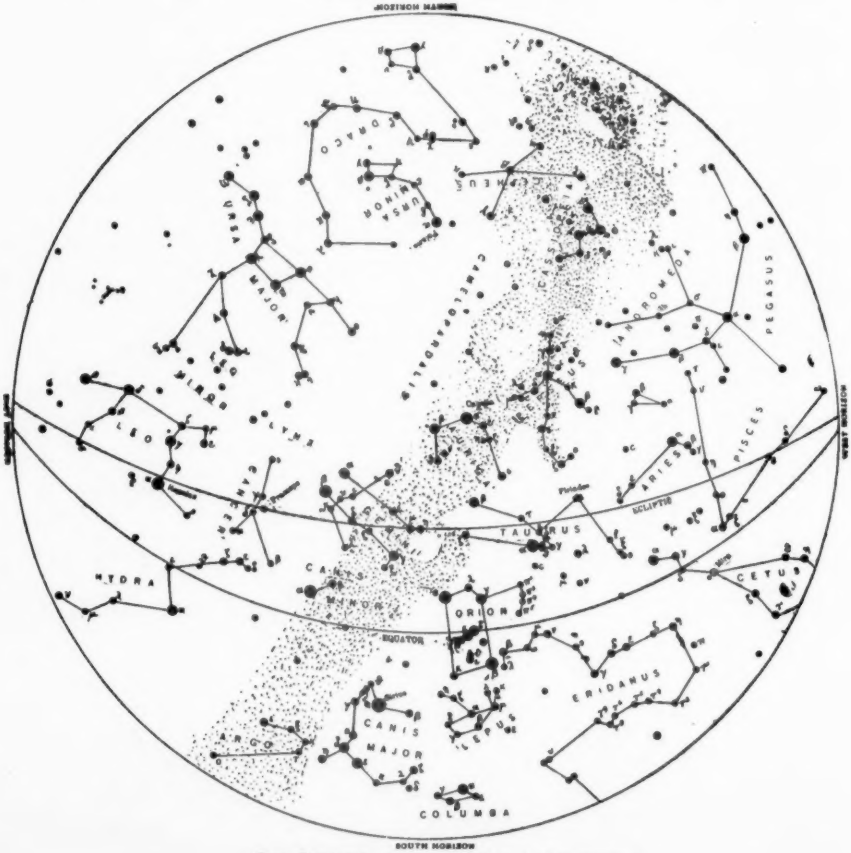
Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

1917	h	m			1917	h	m		
Feb. 3	8	15	I	Tr. I.	Feb. 17	5	44	III	Oc. D.
	9	32	I	Sh. I.		7	52	III	Oc. R.
4	5	35	I	Oc. D.	19	6	42	I	Tr. I.
	9	3	I	Ec. R.		7	53	I	Sh. I.
5	6	10	I	Sh. E.		8	53	I	Tr. E.
7	8	17	II	Tr. I.	20	7	23	I	Ec. R.
9	7	33	II	Ec. R.	23	7	57	II	Oc. D.
10	6	45	III	Ec. D.	25	5	44	II	Tr. E.
	8	26	III	Ec. R.		7	54	II	Sh. E.
11	7	34	I	Oc. D.	26	8	42	I	Tr. E.
12	5	57	I	Sh. I.	27	6	3	I	Oc. D.
	6	53	I	Tr. E.	28	6	26	I	Sh. E.
	8	6	I	Sh. E.		6	32	III	Sh. E.
13	5	27	I	Ec. R.					

Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.



THE CONSTELLATIONS AT 9:00 P. M. FEBRUARY 1.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Lois N. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 February
	h m	° ′		d h	d h d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	27 6
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	4 4; 11 20; 19 13; 27 5
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	1 15; 9 2; 16 12; 23 23
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 13; 14 14; 22 2
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6 19; 12 22; 19 1; 25 3
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	1 22; 9 2; 16 5; 23 9
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 4; 11 0; 17 21; 24 18
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 7; 13 11; 20 15; 27 19
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	5 4; 13 23; 22 17
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	8 9; 16 8; 24 7
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	6 12; 12 6; 17 23; 23 17
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	7 0; 13 19; 20 14; 27 9
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 18; 9 15; 17 13; 25 11
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	3 4; 11 11; 19 19; 28 2
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	6 3; 14 1; 21 22
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	12 0; 25 5
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	8 1; 17 11; 26 22
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	3 22; 16 8; 28 18
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	4 22; 11 14; 18 6; 24 21
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	4 12; 12 17; 20 21
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	1 18; 7 19; 19 20; 25 20
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	6 7; 14 23; 23 15
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	2 8; 12 18; 23 3
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	7 0; 15 0; 23 1
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	2 18; 8 11; 14 5; 25 16
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2 5; 7 19; 19 0; 24 15
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	7 13; 15 18; 23 23
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	4 1; 11 17; 19 7; 26 23
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	6 6; 18 11
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	4 14; 11 18; 18 22; 26 2
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	5 0; 11 20; 18 15; 25 11
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	1 5; 10 12; 19 19
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	4 16; 11 7; 17 22; 24 12
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	8 0; 16 10; 24 20
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	5 13; 11 23; 18 9; 24 20
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	8 5; 15 11; 22 18
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5 5; 13 8; 21 11
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	9 4; 18 16; 28 4
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	3 19; 10 16; 17 12; 24 8
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	3 7; 9 5; 21 2; 27 0
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5 1; 11 18; 18 12; 25 6
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 5; 10 15; 18 1; 25 11
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	3 17; 10 8; 16 22; 23 13
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	5 0; 13 19; 22 14
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	6 11; 13 19; 21 3; 28 11
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	6 9; 13 4; 19 23; 26 17
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	6 22; 14 10; 21 22
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	6 13; 16 4; 25 18
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	3 14; 11 1; 18 12; 25 22
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	7 10; 14 9; 21 9; 28 8

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 February
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	3 11; 10 9; 17 7; 24 5
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	3 23; 12 9; 20 19
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	2 5; 9 21; 17 12; 25 4
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	7 14; 14 22; 22 6
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	7 8; 15 14; 23 20
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	4 17; 13 13; 22 9
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	6 9; 17 11; 27 4
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	4 2; 10 21; 17 16; 24 11
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	5 16; 14 1 ; 22 10
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 1; 12 5; 18 9; 24 12
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	7 4; 14 9; 21 14; 28 19
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	1 13; 8 22; 16 7; 23 16
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 13; 16 17; 24 22
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	1 6; 8 19; 16 8; 23 21
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 5; 11 23; 19 17; 27 11
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	7 12; 15 12; 23 12
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	7 22; 16 11; 24 23
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	4 17; 14 1; 23 9
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	8 0; 18 8; 28 16
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	7 16; 14 22; 22 4
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	1 1; 7 22; 21 18; 28 16
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	13 16 28 19
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4 10; 11 14; 18 18; 25 22
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	4 16; 11 18; 18 21; 26 0
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	3 4; 11 11; 19 18; 28 2
RR Draconis	40.8	+62 34	9.3—13	2 19.9	4 19; 13 7; 21 19
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	3 22; 10 13; 17 5; 23 20
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	9 23; 22 21
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	3 1; 10 17; 18 8; 26 0
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	2 6; 9 20; 17 10; 24 23
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	5 11; 12 16; 19 20; 27 1
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	8 23; 17 22; 26 20
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	1 12; 8 7; 21 19; 28 13
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 4; 10 13; 17 21; 25 6
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	4 6; 9 12; 19 23; 25 5
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5 8; 11 21; 18 9; 24 22
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	3 19; 9 19; 21 19; 27 19
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	4 11; 11 3; 17 18; 24 9
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	6 21; 16 1; 25 4
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	3 12; 11 22; 20 9; 28 19
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	5 2; 11 21; 18 15; 25 10
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	3 17; 10 15; 17 12; 24 10
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	26 7
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	4 10; 14 0; 23 15
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 13; 18 17; 27 22
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	1 5; 8 17; 16 5; 23 16
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 15; 9 5; 16 20; 24 10
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	7 2; 17 4; 27 7
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	6 0; 13 9; 20 18; 28 4
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	7 14; 17 16; 26 23
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	6 21; 14 18; 22 15
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	10 22; 21 1
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	24 13
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5 9; 10 14; 20 22; 26 3
TT Androm.	−23 08.7	+45 36	11.3—12.6	2 18.3	3 15; 11 22; 20 5; 28 12
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	6 10; 13 23; 21 11
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	7 8; 15 14; 23 20

Maxima of Variable Stars of Short Period.

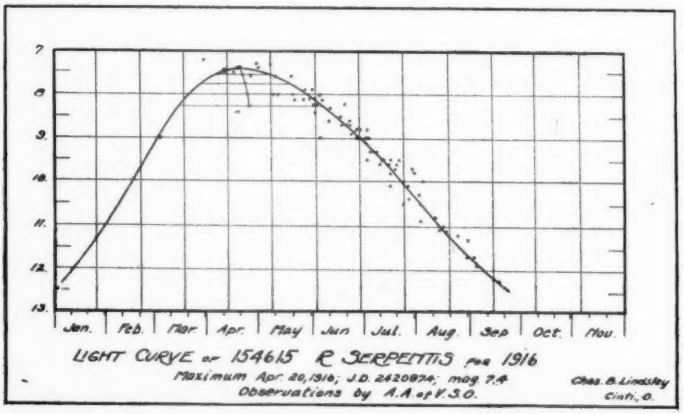
[Calculated by Julia M. Hawkes at Goodsell Observatory.]

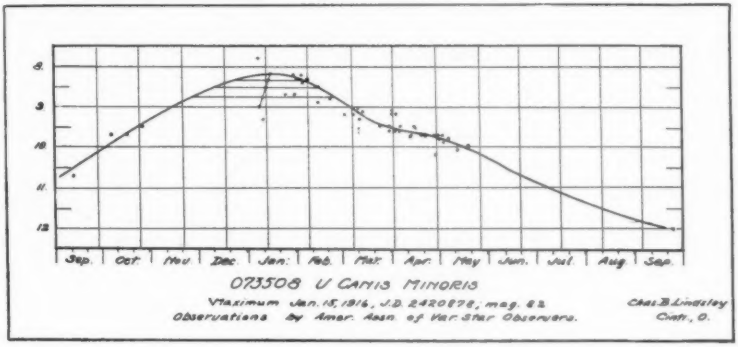
Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1917. February							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7		16 6						
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	5 5;	13 8;	21 11					
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 3;	10 21;	18 14;	26 8				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	5 17		20 12					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 10;	14 8;	22 6					
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	7 3;	14 23;	22 18					
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	6 12;	13 19;	21 2;	28 9				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	5		21					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	9 0;	17 14;	26 4					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	9 14;		20 17					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	8 15;		20 6					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	1 6;	8 22;	16 14;	24 6				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	9 20;		19 24					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	3 4;	10 21;	18 13;	26 8				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	6 0;	11 13;	22 15;	28 4				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	3 10;	10 23;	18 13;	26 3				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		15 21						
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	6 21;	14 8;	21 19					
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	1 23;	9 4;	16 9;	23 14				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	1 12;	9 10;	17 8;	25 6				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	1 12;	11 16;	21 19					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5		12 7						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	4 22;	12 21;	20 20;	28 19				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	6 15;	13 7;	20 0;	26 17				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	7 3;	16 10;	25 17					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	3 7;	12 1;	20 18					
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	4 8;	11 2;	17 21;	24 16				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2 8;	8 22;	22 3;	28 17				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	7 14;	17 6;	26 22					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	8 18;	16 17;	24 17					
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	9 2;	15 19;	22 13					
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	5 19;	11 15;	17 11;	23 6				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4 11;	9 4;	23 6;	27 22				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		14 17						
SS Hydrae	25.0	− 23 08	7.4— 8.1	8 4.8	5 15;	13 19;	22 0					
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 13;	13 14;	20 14;	27 15				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	3 9;	11 14;	19 19;	28 0				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	1 4;	12 3;	23 3;	28 15				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	1 15;	9 5;	16 17;	24 6				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	8 9;	15 18;	23 5;					
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	4 19;	11 13;	18 8;	25 3				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	4 8;	10 15;	16 23;	23 7				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	1 7;	11 1;	20 19					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	9 17;	18 13;	27 10					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	4 1;	10 2;	16 4;	22 5				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 11;	14 12;	21 12;	28 12				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9			17 23					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	6 9;	13 23;	21 13					
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	5 19;	11 14;	23 3;	28 22				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	1 15;	8 9;	31 20;	28 14				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	3 3;	13 11;	23 20					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	1 17;	7 18;	19 19;	25 20				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	6 8;	12 11;	18 14;	24 18				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. February
	h m	° ′		d h	d h d h d h d h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	2 0; 7 23; 19 20; 25 19
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	6 5; 15 7; 24 9
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 1; 8 2; 15 2; 22 3
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	7 4; 14 4; 21 4; 28 4
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	2 14; 10 14; 18 14; 26 13
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	3 9; 11 2; 18 18; 26 11
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	4 10; 11 14; 18 19; 25 23
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	2 8; 10 17; 19 2; 27 11
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	1 19; 8 3; 20 18; 27 2
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	7 5 23 15
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 16; 6 2; 19 10; 23 20
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	3 0; 9 18; 16 11; 23 5
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	1 15; 8 8; 21 18; 28 11
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	9 7; 24 0
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	7 6; 15 3; 22 23
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	4 2; 11 0; 17 21; 24 18
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 23; 8 20; 18 13; 23 10
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	6 10; 15 1; 23 17
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	4 18; 10 3; 20 21; 26 6
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	11 14; 22 12
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	4 16; 11 2; 17 12; 23 23
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	1 10; 6 10; 16 9; 26 8
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	4 2; 9 13; 20 10; 25 21
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	3 14; 9 0; 19 22; 25 9
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 19; 8 2; 20 16; 26 23
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	4 14; 16 18; 28 21
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	5 18; 10 18; 20 17; 25 17





COMET AND ASTEROID NOTES.

Ephemeris of Eros.—A telegram from Professor A. O. Leuschner gives the following ephemeris of Eros, computed by Professor Crawford:—

G. M. T.	R. A.	Dec.
	h m	° ′
1916 December 11.5	11 54.0	+2 23
15.5	12 5.6	−0 2
19.5	12 17.0	−2 28
23.5	12 28.2	−4 54

Eros is probably bright enough to be observed readily. Measures of its brightness are much to be desired.

Harvard College Observatory, Bulletin 619.

Metcalf's Comet.—A cablegram from Professor Elis Strömgren states that the object found by Professor Wolf, and announced by telegraph, is an asteroid, and not Metcalf's Comet.

Mr. Metcalf gives the following precise position of the object announced by him in H. B. 618:—

G. M. T.	R. A.			Dec.			Observer	Place
	h	m	s	°	′	″		
November 21.5673	3	37	58.8	+18	32	0	Metcalf	Winchester

The position for December 22, given in H. B. 618, is erroneous. No other positions of this object have been recesved here.

Harvard College Observatory, Bulletin 619.

Comet *b* 1916 (Wolf).—A telegram, received from Harvard College Observatory on December 25, announces an observation of Wolf's comet (*b* 1916) on December 23. The position given is as follows:—

Gr. M. T.	α	δ
	h m s	° ′ ″
Dec. 23.9734	15 48 54	−5 59 20

According to this observation the ephemeris by Professor Crawford in the Lick Observatory Bulletin No. 286 is very exact, the correction being 0ˢ.0 in α and + 42″ in δ. The portion of this ephemeris for February follows. The parts for December and January were given in the November and December numbers of POPULAR ASTRONOMY.

The comet is described in the telegram as "visible in large telescope."

EPHEMERIS OF COMET *b* 1916 (WOLF).

[From the Lick Observatory Bulletin No. 286].

1917 Gr.M.T.	True α	True δ	log Δ	Br.
	h m s	° ′ ″		
Feb. 1.5	17 06 11.8	−5 03 04	0.4434	8.78
2.5	08 17.8	−4 58 38		
3.5	10 24.2	54 02	0.4379	9.14
4.5	12 31.0	49 16		
5.5	14 38.3	44 20	0.4323	9.51
6.5	16 46.0	39 13		
7.5	18 54.0	33 56	0.4267	9.90
8.5	21 02.4	28 28		
9.5	23 11.3	22 50	0.4210	10.31
10.5	25 20.6	17 01		
11.5	27 30.3	11 02	0.4153	10.73
12.5	29 40.4	−4 04 51		
13.5	31 50.9	−3 58 30	0.4096	11.18
14.5	34 01.8	51 57		
15.5	36 13.1	45 14	0.4038	11.65
16.5	38 24.7	38 20		
17.5	40 36.7	31 14	0.3979	12.14
18.5	42 49.1	23 57		
19.5	45 01.9	16 29	0.3921	12.65
20.5	47 15.1	08 50		
21.5	49 28.6	−3 01 00	0.3862	13.19
22.5	51 42.5	−2 52 58		
23.5	53 56.7	44 45	0.3802	13.75
24.5	56 11.3	36 21		
25.5	17 58 26.3	27 45	0.3743	14.34
26.5	18 00 41.6	18 58		
27.5	02 57.3	09 59	0.3683	14.96
28.5	05 13.3	−2 00 49		
Mar. 1.5	07 29.5	−1 51 28	0.3623	15.60
2.5	09 46.3	41 55		
3.5	12 03.3	32 11	0.3563	16.27
4.5	14 20.6	22 16		
5.5	18 16 38.3	−1 12 08	0.3502	16.97

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, November-December, 1916.

After five years of activity it might be expected that an organization such as ours would begin to show some signs of a diminution in interest; on the contrary, it is most gratifying to note a surprising increase in interest month by month and a continuing accession to our ranks.

This month it is a pleasure to welcome as members of the Association the following gentlemen:—

Mr. Edmond S. McColl, "Mc" New York City.
Mr. William J. Delmhorst, "De" Jersey City, N. J.
Mr. Paul Gmelin, "Gm" Cranford, N. J.
Mr. C. Pardo, "Pa" New York City.
Mr. H. H. Pease, "Ps" Germantown, Pa.

The chief event of interest in the affairs of the Association during the past month was the meeting at the Harvard College Observatory, November 18, when as the guests of the Director, Professor E. C. Pickering, we enjoyed every moment of our stay at this historic institution, and were honored with every attention and courtesy. Space does not permit in this report of a reference to the meeting in detail, but elsewhere in this issue Mr. D. B. Pickering gives a full account of the enjoyable occasion, which will be ever memorable in the annals of the Association, and to all who participated. The Secretary takes this occasion on behalf of the Association to formally thank Professor Pickering and others of the Observatory staff who contributed in such large measure to our pleasure, for our courteous reception and the gracious hospitality extended to us.

Messrs. Burbeck, Bancroft, Lacchini, and McAteer are to be congratulated and commended for lists of exceptional merit contributed to this report.

Mr. Burbeck, in addition to his regular observational work, is making a special study of the variable *184205* R Scuti, and is also observing certain phenomena of the satellites of Jupiter. Any observer who wishes to engage in this work is requested to notify Mr. Leon Campbell of the Harvard College Observatory staff. The only requisite for the work in an accurate time-piece, and the means of checking its rate accurately. Mr. Spinney and Mr. Crane are engaged in checking up the ten day means from the observations of certain variables, thus rendering a valuable service. It is work especially adapted to cloudy evenings when no observing is possible. Mr. Campbell will be glad to inform any members regarding this work.

All the irregular variables are now being well observed for, probably, the first time in the history of variable star observing. Mr. Bancroft deserves great credit for his valuable set of observations of the variable 054319 SU Tauri that marked the sudden decline in the light of this remarkable star.

The present maximum of the Variable *021403 o* Ceti is being exceptionally well observed with a close agreement in the estimates.

Messrs. Delmhorst, Ducharme, and Meeker make their first contributions to the report this month.

Members who have the chart of the Variable 015354 U Persei, are requested to make the following changes:—The 11.5 comparison star should be changed to 11.9, the 8.9 to 9.2, and the 8.2 off the field at the right should be changed to 8.3.

We are indebted this month to Mr. Vogelenzang of Hilversum, Holland, for forty-seven observations contributed to this report, abbreviation "Vo". It is always a

VARIABLE STAR OBSERVATIONS November-December, 1916.

Oct. 0 = J. D. 2421137; Nov. 0 = 2421168; Dec. 0 = 2421198

001032
S Sculptoris

J.D. 242	Est.	Obs.
1179.5	9.7	Ba
87.5	9.6	B

001046
X Androm.

1169.6	<12.8	Bu
87.5	<13.0	Ba

001620
T Ceti

1154.4	6.1	L
64.3	5.8	L
67.3	5.6	L
80.6	5.6	G
82.7	5.7	G
84.7	5.5	G
87.6	5.7	G
90.7	5.7	G

001726
T Androm.

1169.6	<11.8	Bu
79.5	12.9	Ba
82.5	12.8	Y
82.6	12.7	Nt
87.5	13.1	Ba

001755
T Cassiop.

1169.6	11.3	Nt
70.6	10.8	B
79.5	10.9	Ba
79.6	11.8	Bu
83.5	10.4	Nt
87.5	11.0	Ba

001838
R Androm.

1169.6	10.8	Bu
70.6	10.3	B
79.5	11.2	Ba
83.5	9.2	Nt
84.5	<11.0	V
89.5	11.4	Ba
89.6	11.8	M
92.6	10.9	Hu

001909
S Ceti

1170.5	8.7	Nt
78.6	9.0	M
79.5	9.0	Ba
82.7	9.0	Mu
84.6	9.7	Bu
86.6	9.8	S
87	9.0	Mu
87.5	9.0	Ba
92.6	9.9	Hu

003179
Y Cephei

J.D. 242	Est.	Obs.
1179.5	9.1	Ba
83.6	8.8	Bu
87.5	9.2	Ba
93.6	9.2	Hu

004047
U Cassiop.

1179.5	<12.5	Ba
79.6	<12.5	Bu
82.5	<12.8	Y
82.6	12.9	Nt
84.5	13.2	B
89.5	<12.6	Ba
90.5	<12.8	Y

004132
RW Androm.

1169.6	9.8	Bu
70.5	9.9	O
70.6	9.6	B
78.6	10.0	M
79.5	9.6	Ba
84.5	10.4	O
87.5	10.0	Ba
88.6	10.5	Nt
90.6	10.7	Pi
93.6	10.5	Hu

004435
V Androm.

1169.6	11.9	Bu
70.6	12.3	B
79.5	<12.7	Ba
88.6	13.2	Nt
89.6	13.2	Ba
92.6	<12.6	Hu

004533
RR Androm.

1169.6	10.7	Bu
70.5	10.6	O
79.5	11.0	Ba
87.5	11.2	Ba
88.6	11.7	Nt
93.6	11.6	Hu

004746
RV Cassiop.

1179.5	12.4	Ba
79.6	9.2	Bu

004958
W Cassiop

1151.3	10.1	L
64.3	10.8	L
71.5	10.1	B
78.6	10.0	Ba
79.6	10.8	Bu
82.5	10.5	Y
87.5	10.7	Ba
88.6	10.7	Nt
90.5	11.0	Y

010102
Z Ceti

J.D. 242	Est.	Obs.
1170.5	11.3	Nt
73.6	11.0	Bu
79.5	12.1	Ba
87.6	12.6	Ba
89.5	12.5	Y

010940
U Androm.

1169.6	11.6	Bu
79.5	10.5	Ba
87.5	10.3	Ba
90.6	10.6	Pi

011208
S Piscium

1170.5	13.1	B
78.6	<12.4	Bu
87.5	<13.1	Ba

011272
S Cassiop.

1174.5	8.0	B
78.6	7.4	M
78.7	8.0	Ba
79.6	9.0	Bu
87.6	8.4	Ba

011712
U Piscium

1178.6	<12.3	Bu
87.6	12.8	Ba

012350
RZ Persei

1178.6	<11.8	Bu
79.5	<13.0	Ba
87.6	<13.0	Ba
90.5	<12.6	Y

012502
R Piscium

1179.5	7.5	Ba
87.6	7.6	Ba
89.6	7.8	S
90.5	7.7	O
93.6	7.7	M
93.6	9.2	Bu

013238
RU Androm.

1169.6	<12.1	Bu
87.6	12.5	Ba

013338
Y Androm.

1169.6	<12.4	Bu
87.6	10.5	Ba

014958
X Cassiop.

J.D. 242	Est.	Obs.
1179.5	<12.3	Ba
79.6	11.9	Bu
82.5	12.8	Y
82.6	12.4	Nt
87.6	13.0	Ba
88.6	12.1	Nt
90.5	12.4	Y

015354
U Persei

1174.5	8.9	B
78.6	8.1	M
78.6	8.2	Bu
79.6	7.9	Ba
86.6	8.3	V
87.6	8.3	Mu
87.6	8.0	Ba
93.6	8.1	Hu
93.6	9.2	Bu

015556
V Persei

1170	9.2	T

015912
S Arietis

1170.7	13.8	B
78.6	11.6	Bu
87.6	13.7	Ba

021024
R Arietis

1133.4	7.7	Vo
37.3	7.6	Vo
52.3	8.1	Vo
54.2	8.5	Vo
57.3	8.7	Vo
58.3	8.9	Vo
65.3	9.3	Vo
70.5	9.6	O
78.6	9.7	Bu
79.6	10.7	Ba
82.6	10.0	Bu
84	11.4	Me
87.6	10.8	Ba
88.6	10.3	Cr
88.6	11.3	M
89.6	<10.0	S
90.6	11.2	Pi
93.6	10.0	Bu

021143
W Androm.

1196.6	10.8	Bu
89.6	<12.8	Ba

021403
o Ceti

1113.5	<8.0	Vo
32.4	6.8	Vo
33.5	6.8	Vo

o Ceti

J.D. 242	Est.	Obs.
1137.4	6.7	Vo
44.4	5.8	Vo
49.4	5.0	Vo
54.4	4.5	L
56.3	4.3	Vo
57.3	4.2	Vo
58.4	3.9	Vo
59.4	3.9	Vo
61.4	3.7	Vo
61.7	4.7	G
63.4	3.8	Vo
64.3	4.0	L
64.7	4.5	G
65.3	3.7	Vo
66.4	3.7	Vo
67.3	3.7	L
67.4	3.7	Vo
68.3	3.7	Vo
69.3	3.7	L
70.6	3.7	Cr
71.2	3.7	Vo
71.7	4.0	Ly
73.2	3.7	Vo
73.6	4.1	Bu
74.3	3.7	Vo
74.6	4.1	Bu
75.6	3.8	L
76.3	3.7	Vo
76.3	3.6	L
78.6	4.1	Bu
78.6	3.7	Ba
79.6	3.9	Hu
79.6	4.1	Bu
80.6	3.9	G
82.6	4.0	Bu
82.6	3.9	Mu
82.7	3.9	G
83.8	3.9	Mu
84	4.1	T
84.6	3.8	Ba
84.7	3.9	G
85	4.1	T
85.7	3.9	Mu
86	4.1	T
86.6	3.9	D
86.7	3.9	Nt
86.7	3.8	O
86.7	3.8	Mu
86.7	3.8	G
87	4.0	T
87.6	3.8	G
87.6	3.9	Mu
87.6	3.6	Ba
87.6	3.8	Cr
88	4.0	T
88.6	4.0	D
88.6	3.8	O
88.6	4.0	Bu
88.7	3.7	Mu

VARIABLE STAR OBSERVATIONS November-December, 1916—Continued.

o Ceti

J.D. 242	Est.	Obs
1189	3.9	T
89.6	3.8	Mu
89.6	3.8	Cr
89.7	3.8	G
90.5	3.9	O
90.6	3.7	Mu
90.6	3.9	Bu
90.7	3.8	G
91.6	3.7	Mu
91.7	3.8	G
92	4.0	T
92.6	3.9	Hu
92.8	3.7	Mu
93	3.9	T
93.5	4.0	Nt
93.6	3.8	Cr
93.6	3.7	M
93.6	3.9	Bu
94.6	3.8	Cr
94.6	3.7	Ba
95.6	3.7	Bu
96.7	3.6	Mu
97.7	3.6	Mu
98.6	3.8	O
98.6	3.8	Pi
98.6	3.8	Wpi

021658
S Persei

1154.2	10.2	L
78.6	9.9	Bu
79.6	9.1	Ba
87.6	9.1	Ba
87.6<13.3		Me

022001
R Ceti

1173.6<12.0		Bu
87.6	8.1	Ba
88.6	8.4	Nt
88.6	8.4	M
89.5	8.2	Y

022813
U Ceti

1170.6<12.1		Nt
73.6<11.6		Bu
87.6	10.5	Ba

023133
R Triang.

1165.7	8.1	G
69	7.4	T
70	7.6	T
70.5	8.3	O
71	7.6	T
74	7.4	T
79	7.5	T
79.6	7.8	Ba
82.7	7.9	Mu
82.7	8.0	G
84	7.4	T

R Triang.

J.D. 242	Est.	Obs
84.5	7.6	O
86	7.5	T
86.5	8.2	Me
87	7.4	T
87.6	7.5	Ba
87.6	7.7	Mu
88	7.3	T
88.6	7.0	O
88.6	7.6	M
88.6	6.7	Cr
88.7	7.7	G
89	7.5	T
90	7.4	T
90.5	7.3	O
90.6	7.5	Pi
90.7	7.6	G
93	7.4	T
94	7.7	T
94.5	7.0	Cr
94.6	7.0	Hu
94.6	7.3	Bu

024217
T Arietis

1189	10.0	T
90	10.2	T
92	10.0	T

024356
W Persei

1152.3	9.4	L
64.3	9.4	L
67.3	9.4	L
71.6	9.4	M
78.6	9.6	Bu
78.6	9.0	Ba
82.7	9.0	Mu
87.6	9.0	Mu
87.6	8.8	Ba
93.6	9.0	Hu

030514
U Arietis

1178.6<12.6		Bu
87.6<13.7		Ba
90.6<13.1		Y

031401
X Ceti

1170.5	9.3	Nt
73.6	8.5	Bu
79.6	8.7	Ba
86.7	9.0	G
87.6	8.8	Ba
90.9	8.7	Ho
92.6	8.8	Hu
93.6	9.5	M

032043
Y Perse

J.D. 242	Est.	Obs
1154.3	10.0	L
74.5	9.6	B
78.6	9.2	Ba
89.6	8.8	Ba
93.6	8.6	Hu
94.6	9.6	Bu

032335
R Persei

1169.6<10.1		S
70	10.0	T
79.6	9.7	Ba
82.5	10.3	Y
84.6	9.4	S
87.6	8.8	Ba
90.5	8.9	O
90.5	9.3	Y
94.6	8.7	Bu

033362
U Camelop.

1178.6	7.4	Ba
81.5	7.7	Wh
89.6	7.3	Ba
94.6	9.4	Bu

035124
T Eridani

1189.6	9.7	Ba
90.9	9.9	Ho

035915
V Eridani

1189.6	8.5	Ba
90.9	8.5	Ho

042209
R Tauri

1189.6<13.4		Ba
90.7<13.5		Sp
94.6<12.5		Bu

042215
W Tauri

1170.6	10.0	Nt
72.7	10.5	M
73.6	10.2	M
79.6	9.9	Ba
84.6	9.6	Hu
87	10.2	T
87.6	9.9	Ba
87.6<10.3		Cr
88.6	9.8	M
88	9.9	T
89.6	10.4	Wh
92	10.0	T
93.6	10.2	Pi
94.6	10.4	Bu
95.6	9.7	Ba
95.7	9.6	B
98.6	9.8	O
98.6	9.9	Pi

042309
S Tauri

J.D. 242	Est.	Obs
1189.6<13.4		Ba
90.7<13.5		Sp
94.6<12.5		Bu

043065
T Camelop.

1178.6<11.6		Bn
89.5	13.2	Y
89.6	13.8	Ba

043208
RX Tauri

1174.6	9.8	Bu
78.6	9.9	B
84.6	10.9	Hu
86.7	10.5	Ba
89.5	10.6	Y
89.6	10.2	Ba
93.6	10.8	Pi
95.7	10.2	B

043274
X Camelop.

1151.3<11.1		L
54.4	12.6	L
67.3<12.3		L
69 <11.1		T
69.3<12.3		L
70 <11.1		T
71 <11.1		T
78.6<12.3		Bu
79 <11.1		T
84 11.6		T
84.6 12.1		B
85.7<11.1		V
86 <11.1		T
87 <11.1		T
88 11.6		T
88.5 11.5		B
89 11.5		T
89.5 12.0		Y
89.6 11.4		B
89.6 11.5		Cr
89.6 11.6		Ba
90 11.4		T
90.5 11.4		Cr
92 11.6		T
92.6 11.4		Pi
93 11.1		T
94 10.8		T
94.6 11.0		Ba
95.6 11.0		B
98.6 10.4		O
98.6 10.4		Pi
98.6 10.4		Wpi

044617
V Tauri

1169	9.5	T
70.6	10.0	Nt
74.6	9.8	Bu

V Tauri

J.D. 242	Est.	Obs
85.7	9.4	V
86.7	9.5	Ba
89.6	9.3	Ba
93.6	9.4	Pi
95.7	9.5	B

045307
R Orionis

1174.6	10.3	Bu
89.6	13.0	Ba
90.5<12.6		Y

045514
R Leporis

1164.7	7.9	L
72.7	7.8	M
75.6	6.6	L
78.7	6.5	Ba
89.6	6.9	Ba
90.9	7.0	Ho
94.8	7.2	M

050003
V Orionis

1170.6	10.0	Nt
72.7	9.8	M
74.6	9.4	Bu
86.7	10.8	Ba
89.6	10.7	Ba
95.6	11.6	B

050022
T Leporis

1189.6	9.6	Ba
90.9	9.5	Ho
94.8	9.3	M

050953
R Aurigae

1174.6	9.2	B
74.6	9.6	Bu
79.6	9.3	Ba
89	9.3	T
89.6	10.3	Ba
93.5	10.8	Pi
95.6	10.5	B

052034
S Aurigae

1170.6	8.4	B
79.6	8.0	Ba
81.7	8.5	Wh
89.6	8.2	Ba
90.5	9.1	Y
93.5	9.1	Pi
94.6	9.5	Bu

VARIABLE STAR OBSERVATIONS November-December, 1916—Continued.

052036
W Aurigae

J. D. 242	Est.	Obs.
1174.6	<12.0	Bu
79.6	<12.0	Ba
84.6	<13.0	B
86.7	<12.0	Ba
89.6	<13.0	Ba
90.5	<12.0	Y
94.6	<12.8	Ba

052405
S Orionis

1174.6	9.4	Bu
78.7	9.4	Ba
86.7	9.5	Ba
88.6	10.0	D
89.6	9.5	Ba
90.9	9.5	Ho
93.7	9.4	M
95.6	9.2	B
96.0	9.4	Ho

053068
S Camelop.

1169	8.3	T
71	8.6	T
84	8.8	T
87	8.5	T
88	9.1	T
89	8.9	T
90	9.0	T
90.5	8.7	Y
92	8.8	T
92.6	9.5	Pi
98.6	9.0	O
98.6	9.0	Wpi
98.6	9.5	Pi

053005
T Orionis

1174.6	11.0	Bu
75.6	11.0	L
82.7	11.3	Nt
86.6	10.4	Wh
89.6	10.9	Ba
90.7	11.4	Sp
90.9	11.5	Ho
94.8	10.2	M
95.6	10.8	B
96.0	10.7	Ho

053531
U Aurigae

1170.6	10.1	B
79.6	10.7	Ba
85.7	<11.0	V
89.6	11.1	Ba
90.5	10.7	Y
94.6	11.2	Bu

054319
SU Tauri

J. D. 242	Est.	Obs.
1178.6	10.2	Ba
79.6	10.4	Ba
82.7	11.5	Nt
84.6	12.0	B
84.6	12.4	Ba
85.7	<11.1	V
86.7	12.5	Ba
87.6	12.7	Ba
88.6	<12.9	Nt
89.6	12.9	Ba
89.6	<12.0	Cr
89.6	<12.3	Y
89.6	12.9	B
90.6	<12.9	Ba
90.6	<12.1	Cr
94.6	<12.9	Ba
95.6	<12.9	Ba
95.6	<13.0	B
95.7	<12.1	Wh

054920
U Orionis

1171.7	10.1	Ly
74.6	10.4	Bu
76.8	10.3	Ly
79.6	10.4	Ba
84.6	11.0	Hu
88.7	10.3	M
89.6	10.5	Ba
93.6	10.7	Pi

054974
V Camelop.

1174.6	<12.2	Bu
86.7	<13.0	Ba
88.7	<11.3	M
89.5	13.0	Y
89.6	13.6	B
89.6	<13.2	Ba
93.7	<12.2	M
94.6	<13.0	Ba
94.8	<12.2	M
95.6	13.5	B
97.9	<12.2	M
98.6	<11.6	O
98.6	<11.9	Wpi
98.6	<11.9	Pi
98.8	<12.2	M
99.8	<12.2	M

055353
Z Aurigae

1170.6	9.5	Nt
79.6	9.9	Ba
89.5	10.6	Y
89.6	10.1	Ba
93.6	10.8	Pi
94.6	10.7	Bu

060224
S Leporis

J. D. 242	Est.	Obs.
1190.9	6.5	Ho
96.0	6.3	Ho

060450
X Aurigae

1174.6	8.2	B
79.6	8.0	Ba
85.7	9.0	V
89.6	8.3	Ba
90.6	9.0	Wh
93.5	8.9	Pi

060547
SS Aurigae

1154.4	<12.4	L
67.4	<11.6	L
69.4	<12.4	L
70.6	<13.3	B
75.7	<11.6	L
78.5	<12.0	B
79.6	<12.4	B
79.6	<12.6	Bu
84.6	<13.7	B
84.6	<12.8	Ba
86.7	<13.0	Ba
87.5	<11.0	O
87.6	<11.0	Cr
87.6	<13.0	Ba
88.6	<12.6	Bu
88.6	<10.8	O
88.6	<13.8	B
89.5	<13.5	Y
89.5	<13.0	Ba
89.6	<11.4	Wh
89.6	<13.6	B
90.5	<12.4	Cr
90.6	<12.6	Bu
90.6	<13.3	Ba
90.7	13.5	Sp
93.6	<12.4	Cr
93.6	<11.0	Pi
94.6	<12.6	Bu
94.6	<13.3	Ba
94.6	<12.6	Bu
95.6	<13.5	B
95.6	<13.3	Ba
95.6	<13.3	Bu
95.7	<13.0	Ho
98.6	<10.8	O
98.6	<11.4	Pi

061647
V Aurigae

1174.6	8.8	B
90.6	9.6	Ba
95.6	9.3	B

061702
V Monoc.

1189.7	6.6	Ba
90.9	7.5	Ho

063159
U Lyncis

J. D. 242	Est.	Obs.
1189.6	12.6	Y
90.6	12.2	Ba

063558
S Lyncis

1179.6	9.6	Ba
90.6	10.1	Ba
95.6	10.3	B

064030
X Gemin.

1190.6	13.0	Ba

065208
X Monoc.

1164.7	7.9	L
75.7	8.4	L
90.9	9.0	Ho

065355
R Lyncis

1189.5	<13.5	Y
90.6	12.5	Ba

070122a
R Gemin.

1190.6	7.6	Ba
90.7	7.8	Sp
90.7	8.0	D
90.7	8.4	Nt
94.8	8.2	M

070122b
TW Gemin.

1190.6	7.9	Ba
90.7	8.3	D
90.7	8.3	Nt
94.8	8.1	M

070122c
Z Gemin.

1190.6	12.2	Ba
90.7	12.4	D
90.7	12.2	Nt

070312
R Can. Min.

1175.7	10.5	L
76.8	9.4	M
78.7	10.3	Ba

072708
S Can. Min.

1171.7	8.1	Ly
76.7	8.0	Ly
76.8	7.9	M
90.6	7.9	Wh

072811
T Can. Min.

1176.8	9.8	M

073508
U Can. Min

1175.7	10.3	L
76.8	9.7	M
86.7	9.7	Ba
89.7	9.7	Ba

074922
U Gemin.

J. D. 242	Est.	Obs.
1167.4	<10.9	L
69.4	<10.9	L
69.9	<11.7	M
75.7	<12.3	L
86.7	<12.3	Ba
88	<10.5	T
89	<10.5	T
89.6	<13.3	Ba
90.7	<13.7	Sp
90.7	<13.0	Ho
90.7	<13.7	Ba
92	<10.8	T
93	<10.8	T
94.8	<12.3	M
96.0	13.0	Ho
97.8	<12.4	M
98.8	<12.4	M
99.8	<12.4	M

075612
U Puppis

1190.9	<12.5	Ho

081112
R Cancri

1175.7	11.0	L
97.9	10.4	M
98.8	10.4	M

081617
V Cancri

1197.8	7.7	M

082405
RT Hydrae

1175.7	7.9	L

083350
X Urs. Maj.

1174.7	12.2	Bu

082405
RT Hydrae

1199.8	8.8	M

084803
S Hydrae

1198.8	11.6	M

085008
T Hydrae

1199.8	9.7	M

090151
V Urs. Maj.

1164.7	10.3	L
75.6	10.4	L
90.6	10.3	Ba

093014
X Hydrae

1198.8	8.9	M

VARIABLE STAR OBSERVATIONS November-December, 1916—Continued

093934
R Leo. Min.

J.D. 242	Est.	Obs.
1172.9	10.6	M

094211
R Leonis

1164.6	6.2	L
75.7	6.6	L
94.8	7.7	M

094622
Y Hydrae

1199.8	6.5	M

103212
U Hydrae

1164.7	5.1	L
75.7	4.8	L

103769
R Urs. Maj.

1133.3	7.7	Vo
34.3	7.5	Vo
37.3	7.4	Vo
52.3	7.5	Vo
57.4	7.3	Vo
58.4	7.3	Vo
65.3	7.5	Vo
68.3	7.5	Vo
71.7	7.6	Ly
74.7	7.8	Bu
76.8	7.8	Ly
78.5	7.6	Ba
78.7	7.8	Ly
86.7	8.1	S
90.6	8.0	Ba
92.6	8.3	Wa
93.7	8.4	M
95.6	8.2	Ba

104620
V Hydrae

1175.7	7.0	L

115919
R Comae

1194.9	<10.6	M

121418
R Corvi

1194.6	<10.9	M

122532
T Can. Ven.

1194.9	11.0	M

123160
T Urs. Maj.

1171.7	<12.0	Ly
74.7	<12.0	Bu
94.8	11.7	M
95.5	11.1	Ba

123307
R Virginis

1194.8	7.4	M

123459
RS Urs. Maj.

J.D. 242	Est.	Obs.
1194.8	<11.3	M

123961
S Urs. Maj.

1164.7	8.8	L
71.7	9.1	Ly
74.7	9.6	Bu
75.6	9.6	L
78.5	9.5	Ba
80.7	9.3	Ly
81.5	9.4	Wh
86.7	<9.2	S
87.5	9.7	Ba
94.8	11.0	M
95.5	10.3	Ba

133273
T Urs. Min.

1179.6	<12.2	Bu

134440
R Can. Ven.

1152.3	8.7	L
69.6	8.1	M
94.9	7.4	M

141567
U Urs. Min.

1171.5	8.8	S
74.6	8.6	B
78.5	8.0	Ba
84.5	8.2	Ba
88.5	8.6	S
93.5	8.4	Wh

142539
V Bootis

1152.3	9.4	L
68.2	9.4	L
69.6	8.6	M

153378
S Urs. Min.

1152.3	11.5	L
71.7	10.8	Ly
74.5	10.5	B
78.5	10.6	Ba
78.8	10.6	Ly
92.5	11.2	Pi
93.6	11.1	Wh

154428
R Cor. Bor.

1149.3	6.0	L
64.2	6.0	L
67.3	6.1	L
68.2	6.2	L
69.6	6.2	M
76.2	6.0	L
78.5	6.0	Ba

R Cor. Bor.

J.D. 242	Est.	Obs.
1179.5	6.1	Cr
79.5	6.1	Ba
81.5	6.3	Wh
87.4	6.0	Ba
88.5	6.0	Cr
95.5	6.1	Ba

154536
X Cor. Bor.

1195.5	6.3	Ba

154539
V Cor. Bor.

1169.6	10.0	M

154615
R Serpentis

1171.7	<12.0	Ly

155847
X Herculis

1149.3	6.2	L
54.3	6.1	L
64.2	6.1	L
67.3	6.0	L
76.7	5.9	L
80.6	6.4	Mu
86.5	6.0	Ba
87.6	6.4	Mu

160625
RU Herculis

1169.6	10.2	M
87.5	10.9	Ba

161138
W Cor. Bor.

1169.6	11.4	M
71.7	<12.0	Ly

162119
U Herculis

1169.6	10.5	M
71.5	<9.3	S
71.7	10.3	Ly
79.5	10.2	Wh
82.5	10.5	Y
83.5	10.4	Nt
87.5	10.4	Ba

162807
SS Herculis

1150.3	<10.3	L
64.2	10.2	L
68.2	10.4	L
74.5	<11.0	Nt
79.5	10.0	Ba

163137
W Herculis

1182.5	11.3	Y
86.5	10.5	Ba
95.5	9.4	Ba

163172
R Urs. Min.

J.D. 242	Est.	Obs.
1174.5	9.8	B
78.5	10.3	Ba
79.6	10.5	Bu
86.5	10.3	Ba
89.6	10.0	M
92.5	10.5	Pi
93.5	10.4	Wh

163266
R Draconis

1169.6	9.4	S
70.5	9.3	O
71.6	9.4	Ly
74.7	9.6	Bu
76.7	9.1	Ly
78.5	8.2	Ba
79.6	8.4	B
81.6	9.9	Wh
84.5	7.8	Ba
84.5	8.0	O
84.6	8.1	Cr
88.5	8.0	S
88.6	8.0	O
88.6	7.9	Cr
89.5	8.2	Wh
89.6	7.8	Cr
89.6	8.0	M
93.5	8.1	Cr

164055
S Draconis

1178.5	8.1	Ba
89.6	8.3	Wh
89.6	8.7	M

164715
S Herculis

1169.6	10.0	M
87.5	9.0	Ba
95.5	8.7	Ba

165631
RV Herculis

1169.6	11.4	M
82.5	13.0	Y
83.5	<12.6	Nt

170627
RT Herculis

1182.5	<12.6	Y

171723
RS Herculis

1182.5	9.0	V
82.5	8.7	Nt
86.5	8.8	Ba
92.5	8.7	Pi
95.5	8.9	Ba

172808
RU Herculis

J.D. 242	Est.	Obs.
1182.5	9.9	V
86.5	9.6	Ba
95.5	9.2	Ba

175111
RT Ophiuchi

1186.5	<12.0	Ba

175458
T Draconis

1175.6	9.0	B
78.5	9.2	Ba
82.5	10.3	V
89.6	9.8	M

175519
RY Herculis

1182.5	<13.0	Y
83.5	<12.9	Nt

180531
T Herculis

1173.6	11.4	M
86.5	10.0	Ba
92.5	9.5	Pi
95.5	9.5	Ba

180565
W Draconis

1175.6	9.5	B
78.5	10.9	Ba
82.5	11.3	Y
86.5	11.6	Ba
89.6	11.3	Wh

181103
RY Ophiuchi

1187.5	12.3	Ba

181136
W Lyrae

1173.6	11.5	M
75.6	11.0	B
82.7	10.4	Mu
84.5	11.8	B
86.5	12.0	Ba
87.6	108.	Mu
92.5	<11.7	Pi
92.7	11.8	Wh

183225
RZ Herculis

1186.5	12.2	Ba

183308
X Ophiuchi

1149.3	6.8	L
54.3	7.0	L
68.2	7.6	L
73.6	8.1	M
82.5	7.7	V
86.5	7.5	Ba
95.5	8.2	Ba

VARIABLE STAR OBSERVATIONS November-December, 1916—Continued.

184134
RY Lyrae

J.D. 242	Est.	Obs.
1184.5	12.0	Ba

184205
R Scuti

1149.3	5.4	L
52.3	5.4	L
54.3	5.1	G
62.6	5.0	L
64.2	5.0	L
67.3	4.8	L
68.2	4.9	L
69.5	5.4	Bu
70.5	5.3	O
72.5	5.5	D
72.5	5.4	Bu
73.6	5.8	M
72.6	5.1	L
78.5	5.2	Ba
79.5	5.2	Bu
79.5	5.7	Bu
79.5	5.3	Ba
80.6	5.4	Mu
80.6	4.8	G
81.5	5.3	Wh
81.6	4.9	G
84.5	5.7	Ba
84.5	5.6	O
84.7	4.9	G
86.5	5.6	Ba
87.5	5.7	Ba
87.6	5.2	Mu
87.6	4.9	G
89.5	5.8	Pi
93.5	6.0	Bu
94.5	5.9	Bu
95.5	5.8	Ba

184243
RW Lyrae

1184.5 <	13.4	Ba
88.5 <	13.7	B

185032
RX Lyrae

1184.5	12.4	Ba
92.5 <	11.9	Pi

185634
Z Lyrae

1184.5 <	13.0	Ba
95.5 <	13.3	Ba

190108
R Aquilae

1151.3	8.3	L
68.3	8.7	L
69.6	8.0	Bu
74.5	8.3	B
74.6	8.7	M
78.6	8.7	Ba
82.5	9.1	V
99.5	9.9	Ba

190529
V Lyrae

J.D. 242	Est.	Obs.
1184.5 <	12.7	Ba

190926
X Lyrae

1173.6	8.4	M
78.6	10.2	Ba

190967
U Draconis

1189.6	8.5	M
93.6	10.3	Hu

191033
RY Sagittarii

1154.2 <	10.5	L

191350
TZ Cygni

1173.6	11.0	Bu
78.6	10.2	Ba

191637
U Lyrae

1178.6	9.2	Ba
90.5	10.8	Nt
92.5	11.2	Pi

192928
TY Cygni

1173.6 <	11.9	Bu
86.5 <	12.9	Ba

193311
RT Aquilae

1169.6 <	12.0	Bu
86.5 <	13.4	Ba

193449
R Cygni

1170	10.2	T
70.5	10.3	O
73.6	10.0	Bu
74	10.4	T
74.6	9.4	B
78.6	9.5	Ba
83.6	9.9	Me
83.6	10.5	M
84.5 <	10.9	S
84.5	11.1	O
84.6	10.0	Hu
84.6	11.1	Pi
86.5	10.2	Ba
86.6	10.2	Wh
88	10.5	T
95.6	9.5	B

193509
RV Aquilae

1169.6	11.0	Bu
84.5	10.0	Ba
95.5	9.9	Ba

193732
TT Cygni

J.D. 242	Est.	Obs.
1154.4	7.4	L
73.6	8.4	Bu
75.6	7.6	B
78.6	7.4	Bu
84.6	7.4	Hu
84.6	8.0	Pi

194029
SU Cygni

1162.7	6.5	G
82.7	6.7	G
87.6	6.7	G

194048
RT Cygni

1169.6	7.2	S
70	7.4	T
70.5	7.2	O
73.6	7.5	Bu
74.6	7.3	B
78.6	7.0	Ba
83.6	7.4	Me
83.6	7.2	M
84	7.8	T
84.5	7.1	O
84.6	7.0	Hu
84. 6	7.7	Wpi
84.6	7.0	Pi
84.6	7.0	S
86	7.8	T
86.5	7.1	Ba
86.6	7.3	Wh
88	7.8	T
90.5	7.3	O
93.6	8.0	S
95.6	7.7	B
98.5	7.7	Wpi
98.5	7.8	O
98.5	7.8	Pi

194348
TU Cygni

1173.6 <	11.7	Bu
86.5 <	12.8	Ba

194604
X Aquilae

1188.5 <	13.0	B

194632
χ Cygni

1154.4 <	12.2	L
73.6	11.4	Bu
82.5	11.6	Y
84.5	11.0	B
84.5	11.3	Ba
88.5	11.1	B
88.5	11.4	Y
88.6	11.6	O
89.5	11.0	B
94.6	11.1	Ba
95.5	11.0	B
98.5	11.0	Pi

195116
S Sagittae

J.D. 242	Est.	Obs.
1165.7	5.5	G
70.5	5.2	O
80.6	5.9	G
80.6	5.4	Mu
82.7	5.5	Mu
82.7	5.6	G
84.5	5.9	O
87.6	5.4	Mu
90.5	5.8	O

195849
Z Cygni

1170	8.3	T
73.6	10.1	Bu
75.6	10.3	B
78.6	10.3	Ba
82.5	11.1	Y
83.6	10.9	Me
84.5	10.7	B
84.5	11.4	Pi
88	< 9.0	T
90.5	11.2	Nt
94.6	11.5	Wh

200212
SY Aquilae

1182.6 <	12.2	Nt
88.5 <	12.5	B

200357
S Cygni

1173.6	10.8	Bu
79.6	10.4	B
83.6	10.0	M
84.6	10.0	Ba
86.6	10.0	Wh
90.5	10.5	Nt
95.5	9.8	B

200647
SV Cygni

1165.7	9.4	G
73.6	8.5	M
78.6	8.0	Ba
82.7	8.9	Mu
84.6	7.8	Hu
87.6	8.9	Mu
92.6	9.3	Pi

200747
RX Cygni

1182.7	7.8	Mu
87.6	7.9	Mu

200715a
S Aquilae

1149.3	9.4	L
54.3	9.5	L
68.3	9.7	L
70	10.0	T

S Aquilae

J.D. 242	Est.	Obs.
1175.5	9.6	B
83.6	10.7	M
84.6	10.0	Ba
87.6	10.6	Wh
95.5	10.2	Ba

200715b
RW Aquilae

1175.5	9.3	B
83.6	8.6	M
84.6	9.1	Ba
87.6	9.8	Wh
95.5	9.1	Ba

200906
Z Aquilae

1190.5	10.5	Nt
95.5	9.9	Ba

200916
R Sagittae

1170	9.2	T
71	8.9	T
74	9.3	T
75.5	9.1	B
83.6	8.7	M
84.6	9.0	Ba
87	9.0	T
87.6	8.9	Wh
95.5	9.0	Ba

200938
RS Cygni

1154.4	9.2	L
68.3	8.8	L
71.7	8.6	Ly
72.6	8.4	M
73.6	8.3	Bu
78.6	7.4	Ba
78.7	8.5	Ly
84.5	8.2	Pi
98.7	8.3	Ly

201008
R Delphini

1184.5	11.3	Ba
86.6	11.2	Ba
95.5	11.0	Ba

201130
SX Cygni

1173.6 <	12.0	Bu
79.6 <	12.9	B
82.5 <	12.9	Y
86.6 <	12.6	Ba
88.6 <	13.0	Nt

VARIABLE STAR OBSERVATIONS November-December, 1916—Continued.

201521
RT Capricorni

J.D. 242	Est.	Obs.
1152.3	8.0	L
54.3	7.2	L
68.2	8.0	L
87.5	6.9	Ba
89.5	8.0	Pi
95.5	6.9	Ba

201647
U Cygni

J.D. 242	Est.	Obs.
1154.4	10.0	L
65.7	9.9	G
70	9.1	T
73.6	9.2	T
73.6	9.4	Bu
78.6	7.9	Ba
79	9.2	T
82.7	8.2	G
82.7	8.2	Mu
84.5	8.2	Pi
84.6	8.8	S
86	9.5	T
87.6	8.1	Mu
90	9.3	T
90.6	7.9	Wa
93.5	8.2	Cr

202539
RW Cygni

J.D. 242	Est.	Obs.
1172.6	8.5	M
73.6	8.1	Bu
78.6	7.8	Ba
78.6	8.4	Me
79.6	8.4	Wh
92.6	8.9	Pi
98.7	8.9	Ly

202817
Z Delphini

J.D. 242	Est.	Obs.
1186.6	<12.9	Ba

202946
SZ Cygni

J.D. 242	Est.	Obs.
1154.4	9.3	L
69.4	9.3	L
72.6	9.4	M
73.6	9.6	Bu
75.6	9.0	B
78.5	9.5	Ba
79.5	9.3	Ba
79.6	10.2	Wh
84.5	9.0	Ba
84.6	9.6	Hu
86.5	8.8	Ba
87.5	8.7	Ba
89.5	8.7	Ba
90.5	9.0	Ba
92.6	9.8	Pi
94.6	9.6	Ba
95.5	9.9	Ba

202954
ST Cygni

J.D. 242	Est.	Obs.
1172.5	11.1	D
72.6	10.8	Bu
75.6	11.4	B
84.6	11.5	Ba
84.6	11.3	Hu
84.6	11.4	B
90.5	11.8	Nt
92.6	11.9	Pi

203226
V Vulpeculae

J.D. 242	Est.	Obs.
1178.6	9.6	D
78.6	9.3	Ba

203611
Y Delphini

J.D. 242	Est.	Obs.
1179.6	9.5	B
82.5	9.8	Nt
84.6	10.0	Ba
95.5	9.7	B
95.5	10.1	Ba

203847
V Cygni

J.D. 242	Est.	Obs.
1172.6	10.4	M
73.6	10.4	Bu
75.6	8.7	B
84.6	8.6	Ba
90.5	9.6	Nt
95.6	8.7	B

203816
S Delphini

J.D. 242	Est.	Obs.
1182.5	9.9	Y
90.5	9.0	Nt

204016
T Delphini

J.D. 242	Est.	Obs.
1182.5	<13.0	Y
87.5	10.6	Wh
88.6	10.1	Nt

204318
V Delphini

J.D. 242	Est.	Obs.
1182.5	<12.8	Y
82.5	12.8	Nt
86.6	<12.6	Ba

204405
T Aquarii

J.D. 242	Est.	Obs.
1174.5	7.6	Nt
78.6	7.6	B
87.5	7.9	Ba
89.5	8.3	Pi
92.6	9.0	Hu
95.5	8.3	Ba

204846
RZ Cygni

J.D. 242	Obs.	Est.
1173.6	<11.9	Bu
82.5	13.2	Nt
86.6	<13.1	Ba

205017
X Delphini

J.D. 242	Est.	Obs.
1170.5	<13.0	B
95.5	<13.2	Ba

205923
R Vulpeculae

J.D. 242	Est.	Obs.
1184.6	9.8	Hu
86.6	12.2	Ba
89.6	11.8	M

210116
RS Capricorni

J.D. 242	Est.	Obs.
1152.3	8.0	L
68.2	8.1	L
87.5	7.8	Ba
89.5	8.2	Pi
95.5	7.9	Ba

210129
TW Cygni

J.D. 242	Est.	Obs.
1173.6	<12.0	Ba
88.5	<12.7	Y

210868
T Cephei

J.D. 242	Est.	Obs.
1107.4	8.9	Vo
11.4	8.6	Vo
29.3	<8.1	Vo
30.3	8.4	Vo
33.3	8.3	Vo
37.3	8.2	Vo
49.3	8.1	Vo
52.3	6.8	L
56.3	8.1	Vo
57.3	8.1	Vo
58.3	8.1	Vo
65.2	8.0	Vo
69.3	6.8	L
71.2	8.0	Vo
74.6	7.3	Nt
78.6	7.2	B
78.6	6.8	Ba
83.6	6.8	Bu
86.6	7.8	S
93.6	6.6	Hu
93.6	7.2	S

211614
X Pegasi

J.D. 242	Est.	Obs.
1182.6	12.1	Bu
84.6	11.6	Ba
86.6	11.5	Ba
95.5	11.9	Ba

211615
T Capricorni

J.D. 242	Est.	Obs.
1187.5	9.5	Ba
95.5	9.5	Ba

213244
W Cygni

J.D. 242	Est.	Obs.
1150.3	5.5	L
52.2	5.4	L
54.2	5.3	L
67.4	5.2	L
69.4	5.4	L
76.3	5.3	L
84.7	6.2	G
87.6	6.4	G
90.7	6.0	G

213678
S Cephei

J.D. 242	Est.	Obs.
1184.6	12.2	Ba
86.6	<10.2	S

213753
RU Cygni

J.D. 242	Est.	Obs.
1172.6	8.7	M
73.6	8.9	Ba
78.6	8.5	Ba
92.6	9.0	Pi

213843
SS Cygni

J.D. 242	Est.	Obs.
1150.3	10.5	L
51.3	10.1	L
52.2	10.4	L
54.2	10.6	L
65.7	9.5	G
67.4	10.9	L
69.4	11.0	L
69.6	10.7	Bu
69.6	11.3	T
69.6	11.1	Cr
69.6	<9.6	S
70.5	11.2	Nt
70.5	<10.0	O
70.6	11.5	B
70.6	11.7	Cr
70.6	11.4	T
71.6	10.8	M
71.6	10.5	±D
71.6	10.9	Bu
71.7	11.0	Ly
72.6	11.0	Bu
73.6	11.2	Bu
73.6	10.7	M
74.3	10.7	T
74.5	11.1	Nt
74.6	11.2	Bu
74.6	11.3	B
74.6	<9.6	D
74.6	10.5	M
75.6	11.0	B
76.3	10.9	L
76.5	<9.6	D
78.5	11.5	Ba
78.5	11.1	D
78.6	11.2	Bu

SS Cygni

J.D. 242	Est.	Obs.
78.6	11.3	B
78.7	11.5	Ly
79.5	11.3	T
79.6	10.6	Wh
79.6	10.9	Hu
79.6	11.3	B
79.6	11.0	Bu
79.6	11.2	Ba
81.7	11.3	Wh
82.5	11.2	Nt
82.6	11.6	D
82.6	11.2	Bu
82.7	11.2	Mu
82.7	11.2	G
83.5	11.2	Nt
83.6	11.0	M
84.5	11.6	Ba
84.5	11.9	Pi
84.5	<10.4	O
84.6	11.3	Me
84.6	11.0	Hu
84.6	11.4	B
84.6	11.7	Cr
84.6	<9.6	S
84.6	<11.5	D
86.5	11.7	Ba
86.5	11.2	Nt
86.5	11.5	B
86.6	11.4	D
86.6	<11.3	V
86.6	<9.6	S
86.6	11.5	M
86.6	11.6	Bu
86.7	11.3	O
87.5	11.3	Ba
87.5	11.3	T
87.5	11.8	O
87.6	11.3	Mu
88.5	11.3	Nt
88.5	<9.6	S
88.6	11.9	Bu
88.6	11.3	B
88.6	11.7	D
88.6	11.2	T
88.6	12.0	M
89.5	11.6	Pi
89.6	11.7	Wh
89.6	11.6	Cr
89.6	11.5	B
90.5	11.3	Ba
90.5	11.2	Nt
90.6	11.5	Cr
90.6	11.3	D
90.6	11.8	Bu
90.7	11.8	Sp
92.5	9.0	±D
92.6	8.7	D
92.6	8.8	Wh

VARIABLE STAR OBSERVATIONS November-December, 1916—Continued.

SSCygni

J.D. 242	Est.	Obs.
1192.6	9.2	T
92.6	8.9	Me
92.6	8.9	Hu
92.6	8.6	Pi
93.5	8.6	Pi
93.5	8.7	Cr
93.5	8.9	Y
93.6	9.0	Hu
93.6	8.8	S
93.6	8.3	Bu
93.6	8 5	D
93.6	9.1	T
93.6	8.7	M
94.5	9.3	T
94.5	8.8	Cr
94.6	9.1	Hu
94.6	8.6	Bu
94.6	8.6	Ba
95.5	9.0	Ba
95.5	9.1	B
95.6	9.4	Hu
95.6	9.0	WPi
95.6	8.9	S
95.6	8.8	Nt
95.6	8.7	Bu
98.5	10.0	Pi
98.6	10.0	O
98.6	10.0	WPi
98.7	9.7	Ly

213937
RV Cygni

J.D. 242	Est.	Obs.
1169.4	6.9	L
72.6	8.5	M
78.6	6.9	Ba
79.6	7.6	Hu

RV Cygni

J.D. 242	Est.	Obs.
1188	7.7	T
92.6	8.2	Pi
98.7	8.1	Ly

214024
RRPegasi

J.D. 242	Est.	Obs.
1182.6	<12.0	Bu
86.6	<13.0	Ba

215605
V Pegasi

J.D. 242	Est.	Obs.
1173.8	<10.8	M
82.6	<11.9	Bu
86.6	10.1	Ba
89.6	9.0	Y
95.5	9.5	Ba

215934
RT Pegasi

J.D. 242	Est.	Obs.
1182.6	10.1	Bu

220412
T Pegasi

J.D. 242	Est.	Obs.
1182.6	<12.0	Bu
86.6	<12.7	Ba

220613
Y Pegasi

J.D. 242	Est.	Obs.
1182.6	<10.9	V
86.6	<13.6	Ba
89.6	<13.0	Y

220714
RS Pegasi

J.D. 242	Est.	Obs.
1182.6	<10.9	V
82.6	<12.1	Bu
86.6	<13.0	Ba
89.6	12.7	Y

222439
S Lacertae

J.D. 242	Est.	Obs.
1173.8	10.9	M
86.6	9.8	Ba
95.5	9.1	Ba

222557
Delta Cephei

J.D. 242	Est.	Obs.
1180.6	4.0	G

225120
S Aquar i

J.D. 242	Est.	Obs.
1187.5	11.7	Ba
89.5	11.6	Pi
95.5	12.0	Ba

225914
RW Pegasi

J.D. 242	Est.	Obs.
1182.6	<12.5	Bu
86.6	<13.0	Ba

230110
R Pegasi

J.D. 242	Est.	Obs.
1178.6	11.2	Ba
82.6	9.9	Bu
84.5	10.5	O
84.5	10.7	Me
86.6	10.3	Ba
87.5	10.4	O
87.6	10.6	Mu
87.6	10.3	Cr
88.6	10.4	Cr
90.6	10.1	O
90.6	10.1	Pi
92.6	10.0	Wh
93.5	9.7	Cr

230759
V Cassiop.

J.D. 242	Est.	Obs.
1170.5	12.1	Nt
79.6	<12.5	Bu
79.6	11.5	Ba
86.6	10.7	Ba
90.5	10.4	Y

231425
W Pegasi

J.D. 242	Est.	Obs.
1182.6	<12.4	Bu
84.5	<11.4	V
86.6	11.9	Ba

231508
S Pegasi

J.D. 242	Est.	Obs.
1182.5	12.8	Nt
82.6	<12.5	Bu
86.6	<13.0	Ba

233335
ST Androm.

J.D. 242	Est.	Obs.
1179.6	10.7	D
79.6	10.4	Bu
79.6	10.5	Ba
89.6	10.6	S
89.6	11.2	M
90.6	10.9	Pi
92.6	10.0	Hu

233815
R Aquarii

J.D. 242	Est.	Obs.
1154.3	7.3	L
68.3	7.4	L
79.6	7.3	D
79.6	7.2	Bu
87.5	7.8	Ba

'R Aquarii

J.D. 242	Est.	Obs.
1189.5	7.9	Pi
89.6	8.0	Wa
92.6	7.7	Hu
95.5	8.0	Ba

233956
Z Cassiop.

J.D. 242	Est.	Obs.
1179.6	<12.1	Bu
82.6	13.2	Nt
86.6	12.8	Ba

235209
V Ceti

J.D. 242	Est.	Obs.
1188.6	<12.0	Nt

235350
R Cassiop.

J.D. 242	Est.	Obs.
1179.6	<12.2	Bu
87.5	10.9	Ba

235525
Z Pegasi

J.D. 242	Est.	Obs.
1170.5	9.8	O
79.6	9.0	Ba
82.6	9.5	Bu
84.5	8.7	O
84.5	8.8	V
86.6	8.7	Ba
90.5	8.5	O
90.6	8.7	Pi

235939
SV Androm.

J.D. 242	Est.	Obs.
1169.6	<12.3	Bu
86.6	<12.7	Ba
90.5	<12.7	Y
92.6	<12.6	Hu

No. of observations 1417; No. of stars observed 223; No. of observers 26.

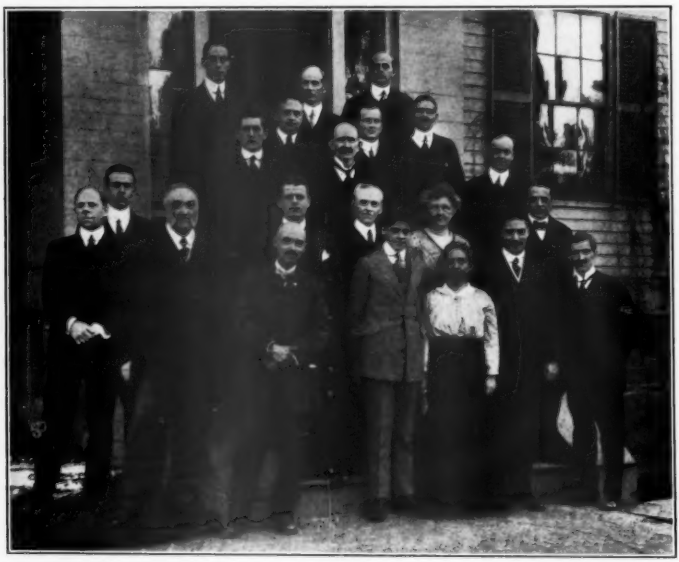
pleasure to have observers across the sea coöperate with us, and a cordial invitation to join the Association is extended to all variable star observers wherever situated.

The fact that the variable 213843 SS Cygni has recorded two successive short type maxima is worthy of note, as it is an occurrence seldom revealed. The average interval between maxima for the past year has been about thirty-five days instead of fifty days, or more, the former fairly established period.

Perhaps the best indication of the increased interest in Astronomy that is marked at present is the fact that, to a brief note on the work of the Association which the Secretary published in the November 4 issue of *The Scientific American* he has to date received fifty-three replies. This seems truly remarkable. Telescopes are in great demand, and, owing to the war, prices are soaring. Many of those who wrote the Secretary have telescopes, and the future promises a large increase in our membership.

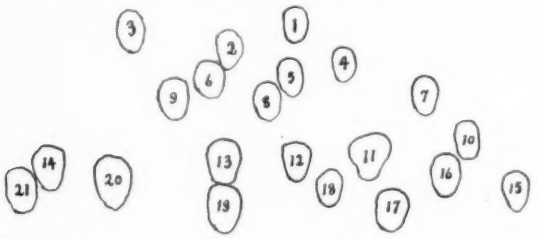
The lists due February, March, and April first, should be sent to Mr. J. J. Crane, Shawme Farm, Sandwich, Mass., and should be sent so that they will surely reach Mr. Crane by the first day of the month. Members will confer a great favor by

PLATE III.



MEETING OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS AT THE HARVARD COLLEGE OBSERVATORY NOVEMBER 18, 1916.

KEY TO GROUP PICTURE



1 D. B. Pickering
2 Rev. T. C. H. Bouton
3 F. L. Ducharme
4 W. T. Olcott
5 F. H. Spinney
6 H. H. Pease
7 R. B. Waterhouse
8 C. T. McAteer
9 E. S. McColl
10 J. J. Crane
11 Miss A. J. Connon
12 A. W. Gregory
13 A. B. Burbeck
14 G. F. Nolte
15 L. Campbell
16 S. C. Hunter
17 Miss I. E. Woods
18 S. W. Pickering
19 S. C. Schulmaier
20 Professor E. C. Pickering
21 F. E. Brasch

complying with this request. The Secretary deeply regrets that he is obliged to give up his duties even temporarily but feels assured that the members will assist Mr. Crane, who has so kindly volunteered to make up the reports, in every way possible. The Secretary expects to return about April 15, and report due May 1 should be sent to him.

A group picture of the members who attended the meeting accompanies this report. Miss Young and Messrs. Mills and Putnam, who were present at the dinner, arrived at the Observatory too late to be included in the photograph. Souvenir cards of the meeting, the gift of Mr. McAteer, were autographed by those present and sent to the active observers who were unable to be with us.

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Crane, de Perrot, Ducharme, Gray, Hoge, Hunter, Lacchini, Lindsley, McAteer, Meeker, Mundt, Nolte, Olcott, D. B. Pickering, S. W. Pickering, Spinney, Vrooman, Waterhouse, Whitehorn, Yendell, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Secretary.

Norwich, Conn., December 10, 1916.

The Annual Meeting of the American Association of Variable Star Observers.—On Saturday, November 20th, the members of the American Association of Variable Star Observers held their fourth annual meeting at the Harvard College Observatory, and in commemoration of his fortieth anniversary as Director, were most hospitably entertained at dinner by Professor Edward C. Pickering.

In the afternoon a group photograph was taken on the library steps, including, besides the members of the Association, the Director, Miss Annie J. Cannon, Miss Ida Woods and Mr. Leon Campbell.

The progress of the variable star work of the Association and that of the Observatory was then shown and explained to the members.

Among some of the exhibits which were recently on display at the National Academy meeting at the Massachusetts Institute of Technology was the result of the work of Allan B. Burbeck in his discussion of the variable star R. Scuti; that of John J. Crane in compiling the ten-day means of estimates of R Coronae Borealis and the light curve of the asteroid Eunomia (15) by Mr. Campbell, calculated since its rediscovery independently by three astronomers last August.

Miss Cannon, the greatest living expert in stellar spectrography, explained her method of spectrum classification and Mr. Campbell gave a most interesting talk, illustrated with lantern slides, upon his experiences at the southern station of the Observatory at Arequipa Peru.

Before dining the members gathered to observe with the 12″ Coudé, selecting the celebrated Variable SS Cygni, and thereupon establishing a new astronomical record: for the first time in history, nineteen astronomers, experienced in variable star observing, estimated the brilliancy of the same star, with the same telescope within the same hour; the most remarkable of all, the mean difference of their estimates showed a deviation of only 0.14 of a magnitude.

At dinner the guests found place cards, bearing a golden five-pointed star and the words "Position," "Motion," "Spectrum," "Color," and "Brightness," the five stellar conditions desired to be ascertained. Great interest was shown in the Director's anecdotes of his early experiences and in the very substantial manner in which he showed his appreciation of the work of the Association and his desire for closer co-operation between this work and that of the larger Observatories.

Mr. William Tyler Olcott, the Corresponding Secretary of the Association and supervisor of its activities, extended to the Director a hearty vote of thanks, on behalf of the Association, for his gracious hospitality.

After dinner all repaired to the dome of the 15″ Refractor—the first telescope in the world to be used for celestial photography—and that historic instrument was set in turn upon Jupiter, the Orion Nebula, and Saturn, during which fourteen observers made naked-eye estimates of Mira, *o* Ceti, with an average deviation of only 0.16 magnitude.

It was close upon two A. M. when the members finally reached their quarters in Boston.

The next morning, as many as could do so, availed themselves of an invitation to visit the Whitin Observatory, at Wellesley College, and were there most courteously entertained by the Director, Professor J. C. Duncan; thus ending what proved to be not only the largest but the most profitable and enjoyable meeting in the history of the Association.

The following members attended:—

William Tyler Olcott, Norwich, Conn.
Professor Anne S. Young, Mt. Holyoke, Mass.
F. E. Brasch, Cambridge, Mass.
Edmund Mills, Jersey City, N. J.
Geo. F. Nolte, Weston, Mass.
Chas. Y. McAteer, Pittsburgh, Pa.
Allan B. Burbeck, North Abington, Mass.
Edward S. McColl, Hoboken, N. J.
F. L. Ducharme, Arlington, Mass.
A. W. Gregory, Morristown, N. Y.
F. L. Spinney, Hudson, N. H.
Rev. Tilton C. H. Bouton, Hudson, N. H.
S. C. Hunter, New Rochelle, N. Y.
H. H. Pease, Philadelphia, Pa.
R. B. Waterhouse, Bourne, Mass.
John J. Crane, Sandwich, Mass.
Edwin W. Putnam, New York, N. Y.
H. R. Schulmaier, Berwick, Me.
S. W. Pickering 2d, East Orange, N. J.
D. B. Pickering, East Orange, N. J.

SS Aurigae and SU Tauri.—Mr. A. B. Burbeck telephoned on December 16 that the variable star SS Aurigae, 060547, is now bright. This star is of the class of SS Cygni, and observations during its maximum will be of value.

The variable star SU Tauri, 054319, is now invisible in the 15-inch telescope. Estimates of its brightness, with large telescopes, as compared with adjacent stars, are greatly to be desired. EDWARD C. PICKERING.

Harvard College Observatory, Bulletin 620,
Cambridge, Mass., U. S. A., December 18, 1916.

Nebula Near Nova Persei.—A telegram received December 20 from Harvard College Observatory is as follows:—

Frost telegraphs Barnard found visually December sixteenth faint diffused nebulosity position from Nova Persei twenty seconds westward. Verified by photographs with reflector by Miss Gussee. E. C. PICKERING.

COMMUNICATIONS.

The Lunar Eclipse of July 14, 1916.—The large partial eclipse of the moon on the evening of July 14, 1916, proved to be one of the most interesting and most beautiful astronomical events I have ever witnessed.

I observed the eclipse from the top of a sand dune on the edge of the Atlantic Ocean at Pablo Beach, Fla. When the moon rose at 5:51 P. M., Central Standard time, she was a gorgeous sight—a big, round, rich golden yellow ball, apparently larger than I had ever seen her. I stood spellbound! I had never beheld a more wonderful sight in nature. She seemed to rise up out of the ocean. There were no clouds in the sky, and the rapidity with which the moon moved caused one to realize more fully our movements in space. The atmosphere was so wonderfully clear and my environments so splendid for a full view that I awaited anxiously for the beginning of the eclipse.

At 8:18 P. M., Central Standard time, a shadow-like effect is seen and felt—that strange, wierd, fading light which precedes all eclipses, and through my glasses I could see the approaching shadow of the penumbra covering the northwest limb of the moon. At 9:19 the clear cut rim of the umbra appeared—the moon had plunged into the real shadow of the earth. Gradually the shadow advanced until it reached its maximum at 10:46 o'clock, covering at least four-fifths of the moon's face.

At this time the earth is lighted by only a small crescent of the moon, an amount nearly equal to that of the moon before she reaches her first quarter.

From first to last contact, the lurid copper color hue of the moon was pronounced, and at maximum the true copper color effect was produced. This light is refracted into the shadow by the earth's atmosphere, and the amount may be greater or less according to the quantity of clouds and vapor in the atmosphere around that belt of the earth which the sunlight must graze in order to reach the moon. Just at this instant—this point—where the moon is deepest in the shadow I wish she might stay awhile, to see and feel more fully the grandeur of it all. But nature is never still—never tires in her appalling measures of time and distances, and already the moon is emerging from this position in the earth's shadow. At 12:12 A. M. she quit the umbra,and at 1:14 the penumbra was entirely invisible. The moon was full at 11:40 P. M., during the eclipse and now comes out in her wonderful brilliancy again, and land and water are flooded in her supernal light. From beginning to end of the eclipse the penumbra was especially visible and was one of the most interesting points of the phenomenon—both umbra and penumbra were most marked.

During a lunar eclipse is our only chance of detecting our own shadow—a shadow, at the point where the moon enters it, with a width of 5,700 miles, or about 2⅔ the diameter of the moon. The average length of the earth's shadow is about 857,000 miles. As the moon is distant only about 240,000 miles, this great shadow would much more than cover the moon. The moon on this date falls within three hours of perigee and is nearer to us than at any time during the year, her distance being 222,000 miles, which is only about 500 miles greater than her smallest possible distance from the earth.

One seems to detect this nearness tonight—her greatness, her wonderful brilliancy, her clear cut markings all seem within feeling distance. Here, on the ocean, her path of light reflection is a beautiful sight. It reaches from the edge of these sand dunes across the great billowy ocean direct to the moon.

The tide is rushing in to reach her maximum height at 6:31 o'clock tonight. On account of the nearness of the moon the lunar tide-raising force is 25 per cent

greater tonight than at any time during the year, so the great waves come farther up the sand dunes and rise to greater heights in passionate strength, as if to greet the moon with a welcome of love.

Here, with the sun, earth, and the moon in line, one may realize the forces of nature in action—a phenomenon which is minute and insignificant as compared to the numberless and greater movements of greater bodies in the universe.

The magnificence of this lunar eclipse tonight is worth the living of a whole life —the wonders and beauties in nature are enough to have lived for.

Jacksonville, Fla. JENNIE LYNNE KYLE.

The Detonating Meteor of September 5, 1916, as observed at Fort Worth, Texas (Lat. 32° 43′ N. Long. 97° 15′ W.) The meteor burst into view at 8:05:50 P. M. (7^h 36^m 50^s astronomical day) from a point at 48° altitude, and 282° azimuth. It proceeded to a point in altitude 45°, azimuth 266°, where a violent explosion took place; a remnant probably as great as half the original body proceeded to a point in altitude 42°, azimuth 266°, disintegrating in a second explosion. The sound of the first explosion came to earth 50.2 seconds after the phenomenon occurred, and the second detonation was heard 46.0 seconds after its occurrence Since the meteor was apparently approaching the observer, and final calculations show that it must have been moving in a direction west 58° north, the first detonation (46.0) was attributed to the second, or nearer explosion. Other observers concur with the writer in this assumption.

By trigonometrical calculations it has been found that the meteor first appeared at a vertical height of 14.08 kilometers, or 9.05 miles, and disappeared at a mean height of 10.34 kilometers, or 6.34 miles, maintaining an average velocity of 8.85 miles per second for the 5.31 miles of visibility. By following out these calculations it was ascertained that the meteor came to earth at a point 30.47 miles, slightly west-of-north of Forth Worth, and bits of meteoric composition have been reported from Mingo, Denton County, approximately that distance and direction. The meteor as observed here and at Denton gave opportunity for close study and computation, unusual in its completeness and value. HOWARD H. MARTIN.

Box 1226, Fort Worth, Texas.

Leap Years with 53 Sundays.—The ordinary year has 52 Sundays. If however the year begin on Sunday it will end on Sunday, and so have 53. If it be a leap year, it may begin on either Saturday or Sunday, and have 53 Sundays. The chances are however that leap year will begin on one of the other five days of the week; in that case there would be only the usual 52 Sundays.

The year 1916 was leap year and began on Saturday; it therefore had 53 Sundays. The last year that had 53 Sundays was 1911; that was not a leap year, but began on Sunday. The last leap year that had 53 Sundays was 1888; but that began on Sunday, whereas 1916 began on Saturday. The last year identical with 1916 in all respects was 1876, the year of the centennial of the United States, 40 years ago, which, exactly like 1916, began on Saturday, and had 53 Sundays. The last three instances preceding that were the years 1780, 1820, and 1848. The next two following instances will be 1944 and 1972. It will be noticed that the intervals are either 28 or 40 years.

Beaver Falls, N. Y. FREDERIC CAMPBELL.

GENERAL NOTES.

Mr. Roberdeau Buchanan, astronomer and until five years ago mathematician of the Nautical Almanac office, died at his home in Washington, D. C., on the morning of December 18. He was seventy-seven years old.

Mr. Buchanan was born in Philadelphia, the son of Pay Director and Mrs. McKean Buchanan. He was educated at the Lawrence Scientific School of Harvard University and graduated as B. S. in the class of 1861. He immediately engaged in practice as a civil engineer. His connection with the National Almanac office dates from 1879, since which time until his retirement he made calculations for the almanac.

He is the author of several mathematical works, the best known to astronomers being his "Mathematical Theory of Eclipses."

Sir Frank Dyson, astronomer royal, **Professor R. A. Sampson**, astronomer royal for Scotland and professor of astronomy in the University of Edinburgh, and **Professor H. C. Plummer**, astronomer royal of Ireland and Andrews professor in the University of Dublin, have been elected honorary members of the British Optical Society. (*Science*, December 15, 1916.)

Mr. John A. Brashear and **Mr. Ambrose Swasey,** the two well-known telescope makers, started during the latter part of November on an extended trip through China. Mr. Swasey kindly remembered POPULAR ASTRONOMY with a beautful Christmas card on which has been written, "Hope to spend Christmas in Peking."

Professor W. R. Brooks of the Smith Observatory, Rochester, N. Y., lectured before the members of the Providence Y. M. C. A. on the afternoon of Sunday, November 19 on "Morning and Evening Stars." The lecture, which was profusely illustrated with many beautiful lantern slide views, was enthusiastically received.

The Bruce Medal for the year 1917 has been awarded to Professor E. E. Barnard of the Yerkes Observatory, for his distinguished services to astronomy. This is the fourteenth award of the Bruce gold medal by the Astronomical Society of the Pacific. The formal presentation will be made at the annual meeting of the Society on January 27.

The Hartness Turret Telescope.—At a meeting of the astronomical section of the Wellington (New Zealand) Philosophical Society Dr. C. E. Adams, F. R. A. S., read a paper on the Hartness Turret Equatorial Telescope. The paper was illustrated by lantern slides showing views of the telescope and sections of the turret, as well as other forms of telescopes.

This form of telescope was described in POPULAR ASTRONOMY, Vol. XX, No. 6, June-July, 1912.

The Diameter of Jupiter's Ninth Satellite.—In the *Publications of the Astronomical Society of the Pacific* No. 166 Messrs. Nicholson and Shapley give a note concerning the brightness of Jupiter's ninth satellite. They find its photographic magnitude at mean opposition to be 18.6. Making reasonable assumptions as to the color-index and the albedo of the satellite they determine its diameter as between the limits 11 and 17 miles.

The Adolfo Stahl Lectures.—Mr. Adolfo Stahl, of San Francisco, has given a fund to the Astronomical Society of the Pacific, for the maintenance of a course of popular lectures on astronomical subjects. It is to be known as the ADOLFO STAHL LECTURE FUND of the Astronomical Society of the Pacific. Mr. Stahl has been declared a PATRON of the Society and has been elected to life membership.

Provision has been made for six lectures in the Course during this season, of which two have been already given by Dr. W. W. Campbell, the dates, subjects and speakers being as follows:—

November 10, 1916, *The Solar System*, W. W. Campbell;
December 8, 1916, *Comets*, W. W. Campbell;
January 12, 1917, *A Total Eclipse of the Sun*, R. G. Aitken;
February 9, 1917, *Double Stars and Star Clusters*, R. G. Aitken;
March 9, 1917, *The Nebulae*, H. D. Curtis;
April 6, 1917, *How Astronomical Discoveries are Made*, H. D. Curtis.

All of the lectures will be illustrated by lantern slides and will be free to the public.

It seems that here is an admirable example, worthy to be followed by public spirited men in many cities.

Scientific Amenities.—Our republication in the number for October of the biographical sketch of the late Karl Schwarzschild, appearing in the August issue of *The Observatory* by an English author, indicates our satisfaction that the bitterness of the war may not impair the appreciation of the scientific services by those on opposite sides in the great European struggle. We are pleased to notice in the third part of the present volume (for 1916) of the *Vierteljahrsschrift* of the Astronomische Gesellschaft an extended and highly appreciative review of Sir David Gill's "History and Description of the Royal Observatory of the Cape of Good Hope." This review occupies in fact thirty-five printed pages and is from the pen of Professor Fritz Cohn, Director of the official astronomical computing bureau at Berlin-Dahlem. The detailed description, written with critical insight, by its length indicates the reviewer's recognition of the importance of Gill's contribution to astronomical history, as may be illustrated by the following quotation, taken from the beginning of the review:—

"Gill's 'History of the Cape Observatory' can only be a condensed extract from the Annals and the other publications of that observatory which are in very fresh remembrance of the contemporary scientists. But just such a condensed extract is of great advantage in view of the great compass of those publications. It gives us a picture of the powerful development of the Cape Observatory from its days of small things in the Seventies up to its high position of today, a picture which offers us decisive testimony as to the energy, versatility, and broad vision of the real creator of this high standing, and it will lead the investigator in special fields to undertake a thorough study of the separate publications. The many connecting references, as well as the manifold personal relationships introduced throughout this part, make it very fascinating reading, and they are of a significance not to be underestimated for the later writer of the history of astronomy. But above all, a detailed review is justified, when we think of the younger astronomers who are already distant from that brilliant development and are accustomed simply to enjoy the fruits of that epoch."

To us who are neutrals it can seem only proper and a matter of course that among scientific men the judicial balance of appreciation for their colleagues should be maintained. At the same time we can well realize that, under the fearful strain, men on both sides should lose their normal perspective and be doubtful whether in the future, at least for this generation, it will be possible to resume the pleasant and valuable international congresses of science which have contributed so much to the progress of astronomy in the quarter of a century prior to the great war.